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UNIVERSITY OF ALBERTA

DEPARTMENT OF GEOLOGY

STRATIGRAPHY OF THE CHINCHAGA AND OLDER PALEOZOIC FORMATIONS
OF THE GREAT SLAVE LAKE AREA, SOUTHERN NORTHWEST TERRITORIES
AND NORTHERN ALBERTA

by



Dudley Dennison Rice, B.A.

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

EDMONTON, ALBERTA

September, 1967

UNIVERSITY OF ALBERTA
FACULTY OF GRADUATE STUDIES

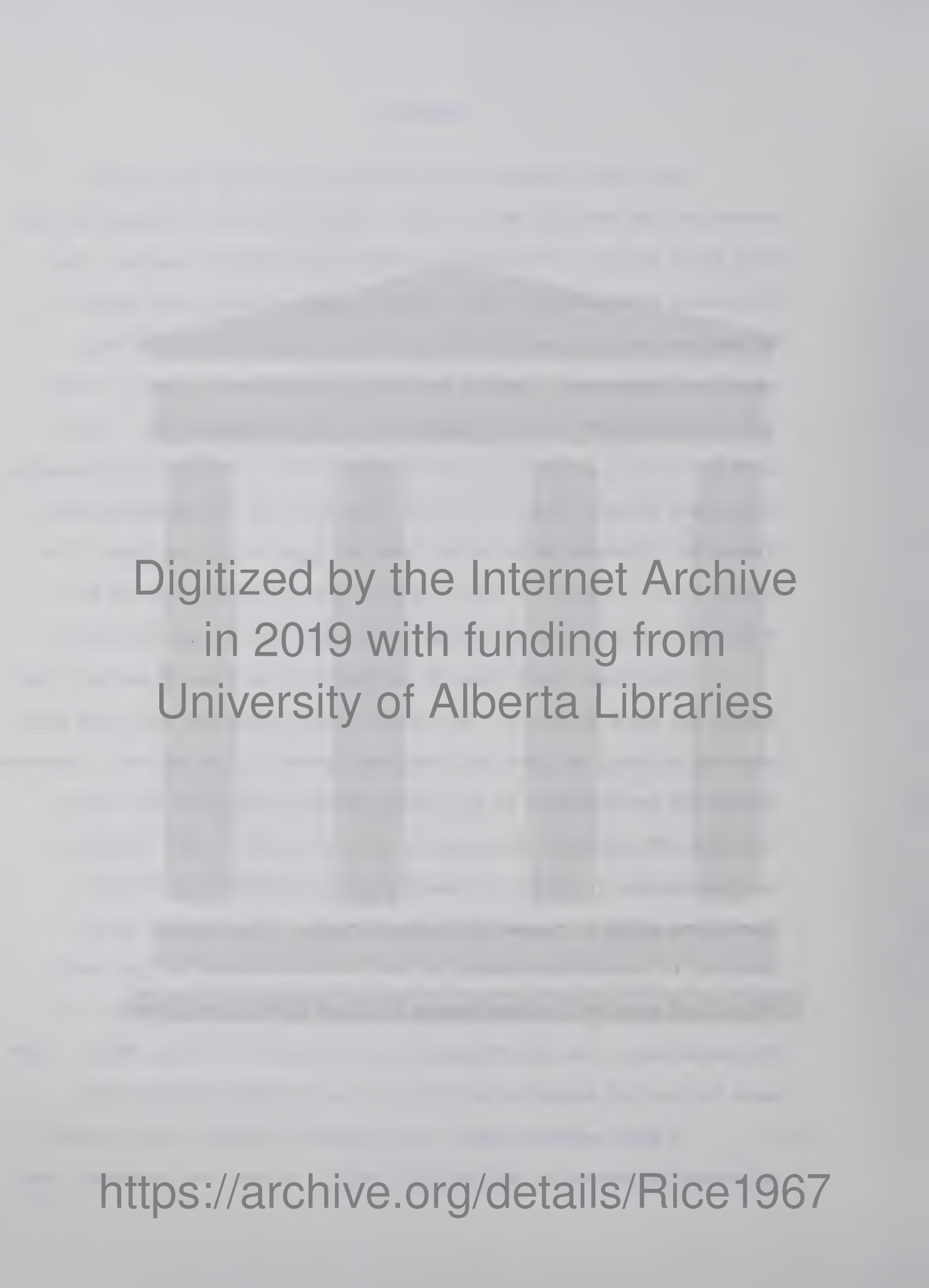
The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Stratigraphy of the Chinchaga and Older Paleozoic Formations of the Great Slave Lake Area, Southern Northwest Territories and Northern Alberta", submitted by Dudley Dennison Rice, B.A., in partial fulfillment for the Degree of Master of Science.

ABSTRACT

The oldest Paleozoic rocks present in the map area are of Ordovician and possible Cambrian age. These rocks are restricted to the area north and west of the Tathlina High-Talston Upland complex. The Ordovician units exhibit facies changes, great thinning, and general convergence in the area of the Snare Sill. Four distinct lithologic units are recognized. The Old Fort Island Formation is a mature basal quartzose sandstone which is deposited in the topographic lows. This unit is overlain by fine-grained clastics of the La Martre Falls Formation which bear a Middle Ordovician fauna in outcrop and the Chedabucto Lake Formation, a massive dolomite unit with an Upper Ordovician fauna. The Mirage Point Formation, a thin evaporite unit developed south of the Snare Sill, is probably equivalent to at least part of the last named.

There were two periods of emergence in the Great Slave Lake area during the Early Paleozoic. At the end of the Ordovician time, the land mass was slightly uplifted and upwarps around the basins were rejuvenated. During the post-Silurian to late Early Devonian interlude, the entire continent was emergent and severe erosion took place. This emergence was accompanied by uplift, deformation, and plutonism in the Western Cordillera which is termed the Cariboo Orogeny. The Cariboo Orogeny resulted in the differentiation of the tectonic elements in the Great Slave Lake area and the development of three intracratonic basins: the Mackenzie Basin, the Bede Embayment, and the Lower Elk Point Basin. These were the site of evaporite deposition in early Middle Devonian time.

A thin carbonate unit, the Fitzgerald Formation, lies directly on Ordovician strata in the Mackenzie Basin. In the Bede Embayment, the



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Fitzgerald Formation overlies a granite wash unit, the La Loche Formation, which rests on the Precambrian. The Fitzgerald Formation is characterized by a unique fauna consisting of the coral Planetophyllum planetum and the ostracode Welleria meadowlakensis which are restricted to this unit. A total of 13 genera and 16 species of ostracodes are described and illustrated from the Fitzgerald Formation in the Slave River area. Comparison of this fauna with other Devonian faunas points toward an Eifelian Age for the unit.

Succeeding evaporites consisting predominantly of halite were deposited in the three basins: the Lower Elk Point Basin and Bede Embayment where they are termed the Cold Lake Formation and the Mackenzie Basin where they are informally designated as the Lower Elk Point Evaporites. The lack of bromide, sulphate, and cycles in the halite indicates that the halite resulted from solution of halite in sea water with subsequent crystallization. It is postulated that solution took place either contemporaneous to deposition by less-concentrated brines or after burial by solutions released during the metamorphism of gypsum to anhydrite.

The overlying Chinchaga Formation, which extends over the entire map area, consists of two informally designated members. The Lower Member, which is developed only in the Mackenzie Basin, consists mainly of anhydrite. The Upper Member is a lateral gradation of limestone to dolomite to anhydrite, going from north to south.

ACKNOWLEDGEMENTS

Dr. D. E. Jackson supervised the study and the writer is grateful to him for his advice and guidance. Thanks are extended to Dr. W. O. Richmond of Pan American Petroleum Corporation for loan of outcrop samples from the Slave River area and information concerning the geology of the area; to Dr. R. C. Green of the Research Council of Alberta and Mr. P. C. McGill of Imperial Oil Limited for help with the study of the ostracode fauna; to Dr. D. Shaw of the Alberta Oil and Gas Conservation Board for analysis of salt samples; and to Dr. C. R. Stelck of the Geology Department of the University of Alberta and Dr. J. P. A. Noble of Pan American Petroleum Corporation for identification of fossils.

The writer extends his thanks to Pan American Petroleum Corporation, Alberta Oil and Gas Conservation Board, Department of Mineral Resources of the Province of Saskatchewan, Cominco Limited, and the Geological Survey of Canada for their contributions to the study.

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CHAPTER ONE

INTRODUCTION

General Statement

Early Paleozoic rocks were first mapped in the Great Slave Lake region by Isbister in 1855. Since that time, many studies have been carried out on the stratigraphy of the Middle Devonian and older Paleozoic rocks outcropping in the region, especially by the Geological Survey of Canada. However, little work has been done on the correlation of the Lower Paleozoic strata in the subsurface.

The Elk Point Group was first described by McGehee in 1949 for a varied sequence of strata of questionable age in the subsurface of the plains of Alberta. This section was shown to underlie a thick section of Upper Devonian rocks and to lie on Ordovician, Cambrian, and Precambrian rocks. Comprehensive studies of faunas and correlations have been made on the upper part of the Elk Point Group as a result of prolific drilling for oil-producing horizons in the section. The Lower Elk Point Subgroup, mainly evaporitic in character, still remains unstudied and a problem as to its age.

The purpose of this study is to make subsurface correlations of the Chinchaga and older Paleozoic formations in the Great Slave Lake region. The study area lies between 57 and 64 degrees north latitude and 111 and 122 degrees west longitude in northern Alberta and southern Northwest Territories. (see figure 1).

The objectives of the study are:

1. Describe the facies, their relationships, distribution, and stratigraphic paleontology.
2. Compare and correlate subsurface sequences with nearby outcrop sections.

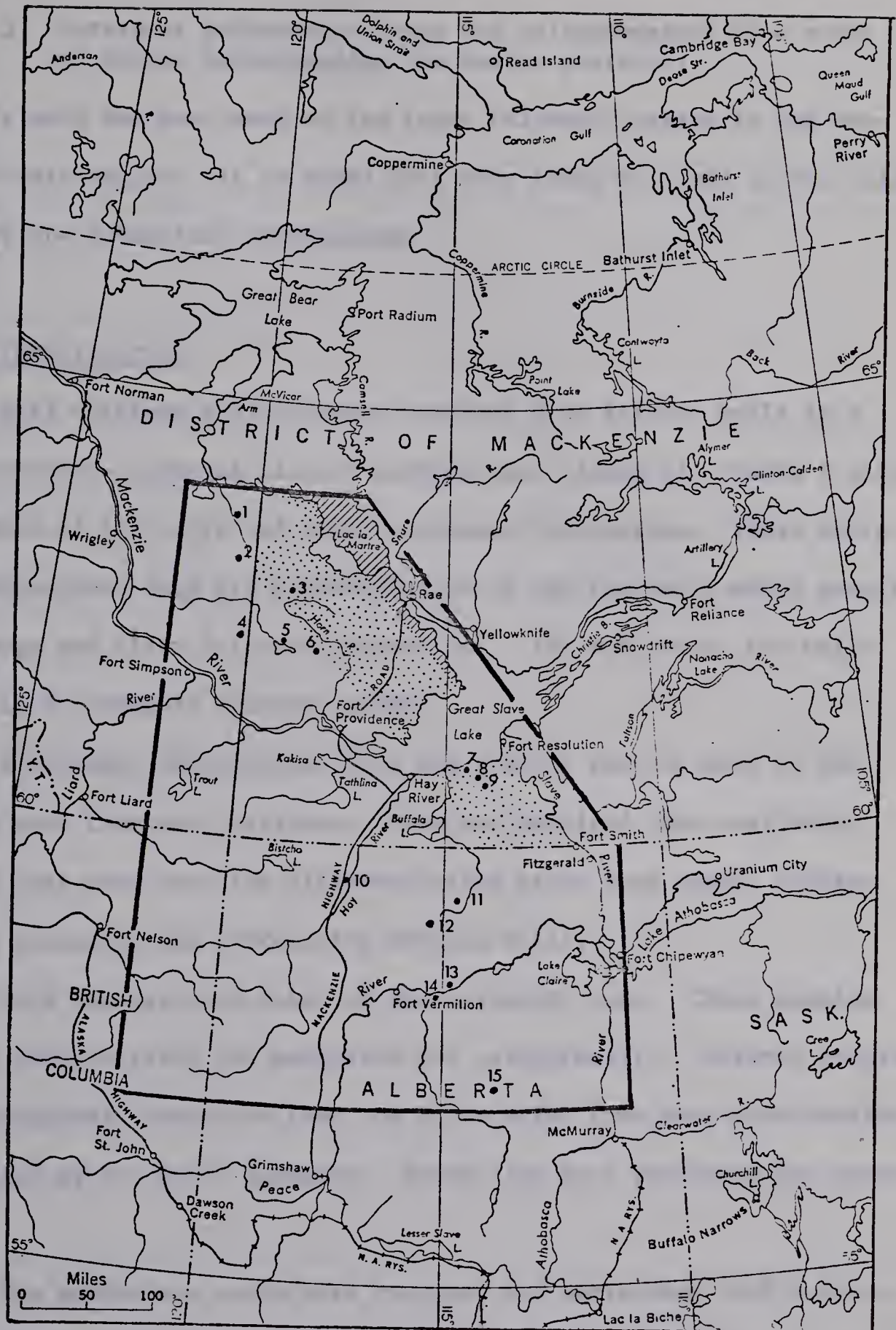


Figure 1. Index map showing limit of study area. Ordovician and possible Cambrian rocks in ruled pattern and Middle Devonian rocks in dotted pattern. Numbers 1-15 represent wells examined.

3. Interpret paleoenvironments and paleogeography as a means of better understanding the facies patterns.

Very little work has been done on the Lower Paleozoic strata in the subsurface of this region. It is hoped that this study will aid in the understanding of the subsurface stratigraphy.

Method of Investigation

Well cuttings and cores were examined from fifteen wells in a general northwest-southeast line of section (see figure 1). Table 1 gives the locations of the wells and other pertinent information. These wells were chosen because they are representative of the few wells which penetrate the Chinchaga and older Paleozoic formations. All but two of the wells terminate in Precambrian basement rocks.

Lithologic descriptions from the greater part of most of the wells were made from well cuttings. Core was examined when available. Mechanical logs were used for differentiating gross rock types, picking lithologic contacts, and correlating between wells.

Core samples were taken of the carbonate beds. These samples were later disintegrated and macerated for microfossils. Outcrop samples from the Fitzgerald Formation from the Slave River area were made available to the writer by Dr. W. O. Richmond. These also were processed for microfossils.

The subsurface units were compared and correlated with outcrop sections described by Norris (1963, 1965) and Richmond (1965).

Basin configuration and facies distribution were studied by isopach and lithofacies maps and stratigraphic cross-sections. Access to well card files was made available by Pan American Petroleum Corporation.

TABLE 1

WELLS EXAMINED

Well Name and Location	K.B.	Interval Studied
1. Imperial Lac Tache C-35 63°44'15"N. 120°36'45"W.	1014'	300-1,719'
2. Imperial Cartridge F-72 63°11'19"N. 120°29'04"W.	1429'	900-2,258'
3. Imperial Windflower G-77 62°56'23"N. 118°59'00"W.	903'	300-1,644'
4. Imperial Triad Harris River F-71 62°20'21"N. 120°14'30"W.	2,343'	2,200-3,314'
5. Imperial Triad Willow Lake B-20 62°17'13"N. 119°04'20" W.	2,438'	2,200-3,150'
6. Imperial Triad Davidson Creek P-2 62°11'45"N. 118°15'05"W.	2,085'	1,850-2,737'
7. Cominco G-4 60°54'00"N. 114°46'00"W.	G.E. 539'	700-1,355'
8. Cominco G-1 60°51'05"N. 114°24'30"W.	G.E. 724'	650-1,181'
9. Pyramid 202A 60°47'42"N. 114°13'49"W.	G.E. 670'	550-1,138'
10. Pan American Whitesands A-1 12-20-122-10W5	1,784'	3,400-3,873'
11. Imperial Jack Lakes No. 8-17 8-17-120-1W5	1,442	2,050-2,638'
12. Pan American Pitchimi Lake A-1 16-11-117-4W5	2,290'	3,400-3,952'
13. Home et al. Wood Buffalo No. 14-22 14-22-110-1W5	830'	1,950-2,428'
14. Home et al. Fox Lake No. 4-30 4-30-108-4W5	862'	2,500-2,988'
15. Calstan Mikkwa River No. 12-23 12-23-98-21W4	2,259'	2,600-3,840'

Previous Work

Isbister (1855) presented one of the first geologic maps of the Great Slave Lake region. He showed Precambrian (crystalline), Silurian, and Devonian rocks in the area.

G. M. Dawson (1887) compiled a geologic map of the northern portion of Canada east of the Rocky Mountains. In the Great Slave Lake area, he reported Devonian strata with the possibility of Silurian rocks along the edge of the Archean Shield.

In 1891, McConnell summarized the work of many of the early explorers. He investigated the southern and western shores of Great Slave Lake in the summer of 1886 and noted Devonian and possible Silurian rocks in the region.

Camsell (1917) studied the gypsum deposits of the lower part of the Peace River, Slave River, and the Salt River and gave a brief report on the section exposed on the Stony Islands in northern Alberta.

Cameron (1917) made a reconnaissance survey of the West Arm of Great Slave Lake during the summer of 1916 and noted that the area was underlain by rocks of Devonian age. Cameron continued his survey during the summer of 1917 which was published in 1918. In it he referred to both Middle Devonian and Upper Silurian strata being present in that area.

In 1922, Cameron reviewed the geological knowledge of the region and provided an up-to-date geologic map of the Great Slave Lake area based on fossils collected and identified by E. M. Kindle, E. J. Whittaker, and himself. Cameron recognized two rock units of Silurian age unconformably underlying Middle Devonian rocks.

Hume (1926) acknowledged the presence of both Ordovician and

Silurian rocks after a detailed study of the fauna. The cephalopods which Hume collected from the Ordovician and Silurian were described by Foerste (1926).

The Geological Survey of Canada conducted a reconnaissance study by helicopter in 1957 called "Operation Mackenzie" (Douglas, 1958) which covered a 100,000 square-mile area in the southern district of Mackenzie. This reconnaissance plus additional work has resulted in publications in the study area by Douglas (1959), Douglas and Norris (1960), Belyea and Norris (1962), and Norris (1963, 1965).

Richmond commenced a doctoral study of the Paleozoic stratigraphy of the Great Slave Lake area in 1960 (circa) which resulted in an unpublished Ph.D. thesis in 1965.

The original work on the Elk Point Formation was done by McGehee in 1949. The name was introduced for a cyclic sequence of red and green shale, anhydrite, dolomite, thin fossiliferous limestone, and salt that lies between the Upper Devonian Waterways Formation and Ordovician, Cambrian, or Precambrian rocks in the plains of Alberta and Saskatchewan. McGehee (1949) dated it as Silurian, but later he (1954) placed it in the Middle Devonian. Belyea (1952) raised the Elk Point to group status. Crickmay (1954) subdivided the section in the Anglo-Canadian Elk Point No. 11 well (2-21-57-5W4th mer.) into nine numbered units.

Workman (1953) described the Elk Point Group in the Peace River Arch area. Law (1955) introduced new formational terminology for the lithologic units of the Elk Point Group in northwestern Alberta. Hunt (1954) and Belyea and Norris (1962) applied new nomenclature to the northern Alberta section. Sherwin (1962) subdivided the Lower Elk Point

Subgroup in east-central Alberta and correlated the units into northern Alberta.

For a more detailed account of previous work, refer to Norris (1963, 1965) and Richmond (1965).

CHAPTER TWO

STRATIGRAPHY

The succession of early Middle Devonian and older Paleozoic rock units in the Great Slave Lake region is presented in Table 2. Figures 2, 3, 4, 5 and 6 present the distribution and relationship of facies. Inferred regional correlations are given in Table 3.

ORDOVICIAN AND POSSIBLE CAMBRIAN

The oldest Paleozoic rocks present in the map area are of Ordovician and possible Cambrian age. These rocks are restricted to the area north and west of the Tathlina High-Talston Upland complex (see fig. 7). These rocks exhibit facies changes, great thinning, and general convergence in the area of the Snare Sill (see fig. 7). The clastic-carbonate-evaporite succession consists of four distinct lithologic units named in ascending order: Old Fort Island Formation, La Martre Falls Formation, and Chedabucto Lake Formation. The Mirage Point Formation, which is developed south of the Snare Sill (see fig. 7), is probably equivalent to at least part of the last two.

Hume mapped the North Arm of the Great Slave Lake in the summer of 1920. He described in a preliminary report two pre-Devonian formations both of which he assigned to the Silurian (Hume, 1921, p. 33). After a detailed study of the fauna was made, the lower dolomite unit which becomes evaporitic to the south was placed in the Ordovician (Hume, 1926, p. 59; Foerste, 1926, p. 65). The younger Fitzgerald Formation which carried the Pycnostylus fauna remained in the Silurian. The Geological Survey of Canada

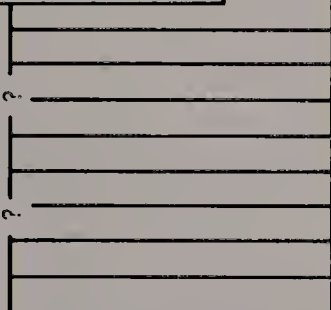
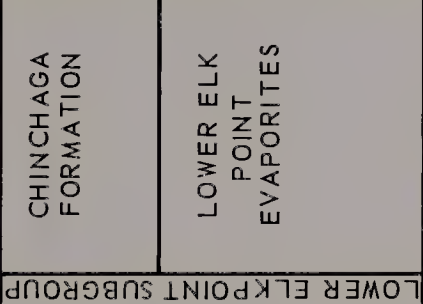
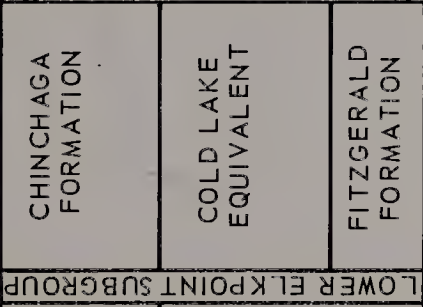
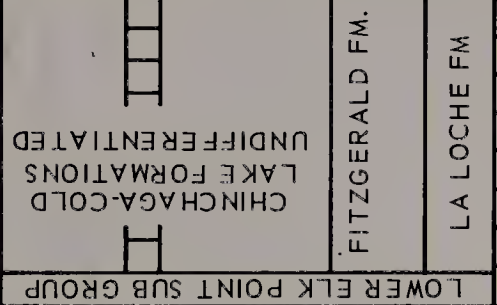
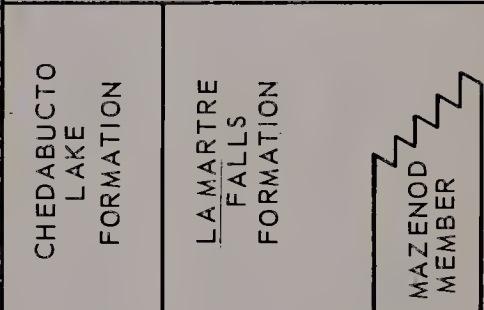
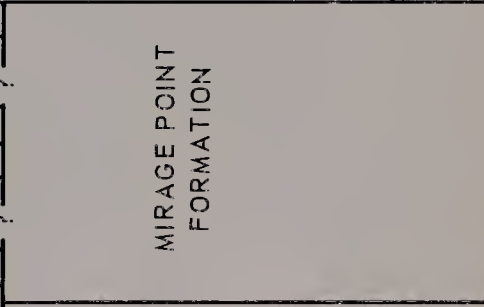
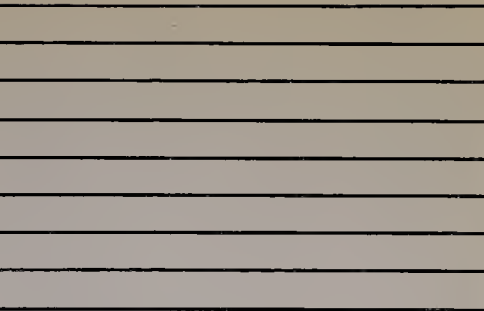
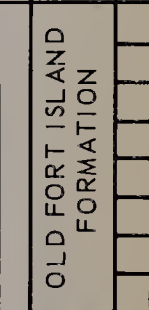
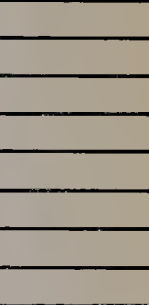
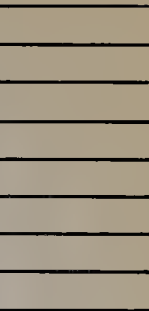
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PALEOZOIC	DEVONIAN								
							MIDDLE	GIVET	EIFFELIAN
	ORDOVICIAN								
							MIDDLE	UPPER	
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TABLE 2. CORRELATION CHART OF THE CHINCHAGA AND OLDER PALEOZOIC FORMATIONS, GREAT SLAVE LAKE AREA, SOUTHERN NORTHWEST TERRITORIES AND NORTHERN ALBERTA (VERTICAL RULINGS DENOTE LACUNA)

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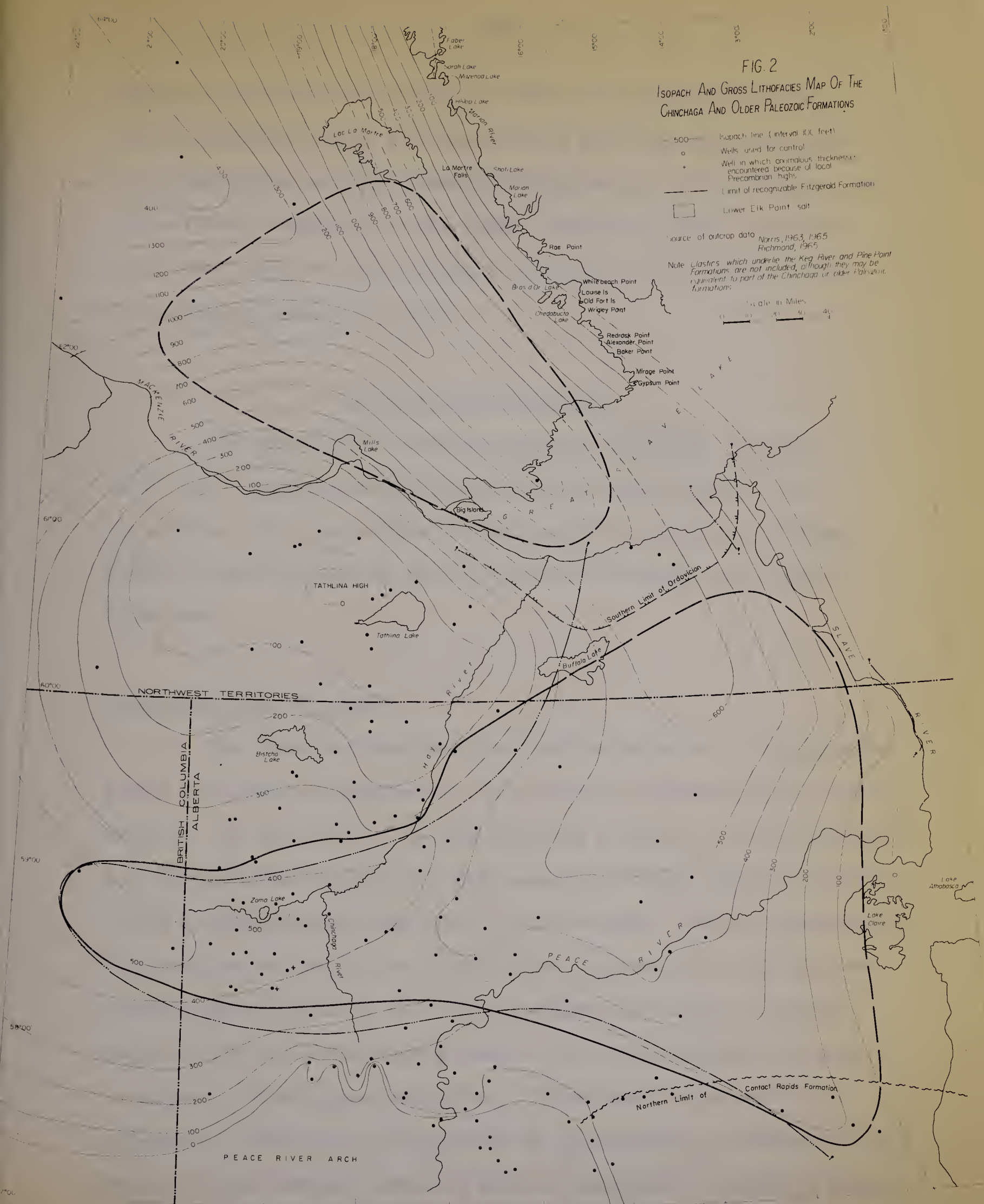
FIG. 2
ISOPACH AND GROSS LITHOFACIES MAP OF THE
CHINCHAGA AND OLDER PALEOZOIC FORMATIONS

- 500 — Isopach line (interval 100 feet)
- o Wells used for control
- + Well in which anomalous thickness encountered because of local Precambrian highs
- Limit of recognizable Fitzgerald Formation
- Lower Elk Point salt

Source of outcrop data Norris, 1963, 1965
Richmond, 1965

Note: Clastics which underlie the Keg River and Pine Point Formations are not included, although they may be equivalent to part of the Chinchaga or older Paleozoic formations.

Scale in Miles
0 10 20 30 40



mapped the Great Slave Lake region in 1957 in "Operation Mackenzie". Several Geological Survey of Canada reports deal with the stratigraphy of the Ordovician and older rocks including: Douglas (1959), Douglas and Norris (1960), Belyea and Norris (1962), and Norris (1965). Richmond (1965) also refers to the Ordovician and possible older strata in his reconnaissance study of the area.

Old Fort Island Formation

The name Old Fort Island Formation was proposed by Norris (1965) for a quartzose sandstone which unconformably overlies the Precambrian. The type section for the formation is on Old Fort Island which is located mid-way up the west shore of the North Arm of Great Slave Lake.

Distribution and Thickness

The formation represents the basal sandstone which was deposited during the initial transgression of the sea over the irregular Precambrian surface. The deposition of the sandstone was restricted to the topographic lows on the Precambrian surface thus accounting for the variable thickness of the formation ranging from zero to over 100 feet. The best exposures of the formation are on Old Fort Island where a maximum of 28 feet has been measured (Norris, 1965, p. 15). The formation also crops out south of Wrigley Point and on the eastern island of the Louise Islands. Nowhere is a complete section exposed in outcrop. The northern extension of the formation is suggested by the presence of talus blocks of sandstone on the shores of Shoti and Tumi Lakes and along an escarpment southwest of Mazenod Lake (Norris, 1965, p. 15).

In subsurface, the Old Fort Island Formation extends from Imperial Triad Davidson Creek P-2 well in the north to the south shore of Great Slave Lake. In Northwest Windy Point No. 1 well ($61^{\circ}19'N.$, $115^{\circ}52'W.$), the nearest well to outcrop, 110 feet of sandstone were encountered (Cameron, 1922, p. 16). On the south shore of Great Slave Lake, the basal sandstone is 101 and 108 feet thick in Cominco G-4 and Pyramid 202A drill holes respectively. The upper contact has been adjusted upward relative to that of Norris (1965, p. 16) in the Cominco G-4 drill hole. In the Cominco G-1 drill hole, situated between the two previously mentioned drill holes, the top of the Precambrian is considerably higher and the basal sandstone unit is missing. Thicknesses of the Old Fort Island Formation encountered in wells included in cross-section A-A' are as follows:

Imperial Triad Davidson Creek P-2 (15 feet)

Imperial Triad Willow Lake B-20 (28 feet)

Imperial Triad Harris River F-71 (22 feet)

Lithology

At the type section, the Old Fort Island Formation consists of fine- to coarse-grained, varicolored but mainly white, friable, quartzose sandstone with some thin beds of greenish gray and dusky red siltstone and occasional green shale partings (Norris, 1965, p. 15). Iron staining is present in some beds, especially along bedding planes and laminae.

In subsurface, the formation consists of a very fine- to coarse-grained, white to red, locally argillaceous, silty and dolomitic, quartzose sandstone. Minor interbeds of red shale and siltstone are also present.

In the Cominco G-4 drill hole, blebs of anhydrite are present in the upper part of the formation. Cross-bedding is present locally in the quartzose sandstone assigned to the Old Fort Island Formation in the Pyramid 202A drill hole with iron staining present along the bedding planes.

Nature of Contacts

The Old Fort Island Formation nonconformably overlies the Precambrian. The formation is overlain by the Mirage Point Formation with a gradational and probably conformable contact. The upper contact of the Old Formation Island Formation is picked at the top of a quartzose sandstone unit below a predominantly shale unit with minor dolomite.

Fossils and Age

No fossils have been collected from this unit in surface or subsurface. It is limited above by the Mirage Point and La Martre Falls Formations, the latter contains a Middle Ordovician fauna in outcrop (Norris, 1965, p. 20). The formation is limited below by the Precambrian. The formation is therefore dated as Middle Ordovician or older.

Correlation and Synonymy

Fuller and Porter (1962, p. 462) compared the Old Fort Island Formation to the Upper Cambrian Deadwood Formation of the Williston Basin. The Deadwood Formation at its type locality in the Black Hills, South Dakota is brown and red, micaceous, glauconitic deposits of sandstone, shale, and impure limestone (Fuller, 1961, p. 1337). At its type section at the

southern end of Lake Winnipeg, Manitoba, the Winnipeg Sandstone is a well-sorted, rarely micaceous, usually weakly cemented, quartzose sandstone (Baillie, 1952, p. 9). The sections described from outcrop and subsurface appear to have a lithology more typical of the Middle Ordovician Winnipeg sandstone and also have an equivalent stratigraphic position.

The writer agrees with Baillie's (1952, p. 39) interpretation that following the late Early to early Middle Ordovician emergence, the sea slowly transgressed over the Precambrian Shield. The detritus was reworked and deposited as a mature quartzose sandstone. This widespread sandstone is represented by the St. Peter Formation in Iowa and Illinois, the lower part of the Simpson Group in Kansas and the Winnipeg Formation in Manitoba. These deposits represent the basal deposits of a transgressing sea but are not necessarily of the same age.

The writer disagrees with Norris' (1965, p. 17) interpretation that the Old Fort Island Formation is analogous to the La Loche Formation of northern Alberta which will be discussed later in the text. Both formations unconformably overlies the Precambrian. However, the Old Fort Island Formation is a well-sorted, mature, quartzose sandstone conformably overlain by Middle Ordovician rocks. The La Loche Formation, on the other hand, is a poorly sorted granite wash overlain by much younger Middle Devonian strata.

La Martre Falls Formation

The name La Martre Falls Formation was proposed by Norris (1965) for a highly variable sequence of red beds. Included within the lower part of the formation is a distinct dolomite unit, named the Mazenod Member, which will be discussed later. The type section is located in the canyon

of Riviere la Martre immediately below La Martre Falls located north of Great Slave Lake.

Distribution and Thickness

The La Martre Falls Formation is discontinuously exposed in a narrow sinuous belt which extends from the northern limit of the map area where it is widest south to Redrock Point (Norris, 1965, p. 17). The formation is thickest in the north in the area west of Hislop Lake where Norris (1965, p. 18) estimated 345 feet of section to be present. The formation thins to the south where only 30 feet of section are exposed between Old Fort Island and Redrock Point along the west shore of the North Arm of Great Slave Lake. The formation locally thins against Precambrian highs (Richmond, 1965, p. 380).

In subsurface, the formation is recognized in the three most northern wells shown in cross-section A-A', Imperial Lac Tache C-35, Imperial Cartridge F-72, and Imperial Windflower G-77 where the formation is 429, 214, and 465 feet thick respectively. This is considerably northwest of the southern limit as mapped by Norris. However, the beds in the equivalent stratigraphic position in the subsurface south of the Snare Sill are evaporitic (see fig. 3) and probably correlate with both the La Martre Falls Formation and the overlying Chedabucto Lake Formation. These rocks are mapped as a separate unit, the Mirage Point Formation.

Lithology

In outcrop, the La Martre Falls Formation consists of a highly variable sequence of red beds comprising shale, mudstone, sandy and

argillaceous dolomite, sandstone, gypsum, and salt. Some beds show primary slumping, brecciation, ripple-marking, and scour structures along with salt crystal moulds which is evidence of shallow water and subaerial deposition (Norris, 1965, p. 17).

In Imperial Lac Tache C-35 well, the formation consists of 214 feet of gray quartzose sandstone and gray to green sandy dolomite with minor green dolomitic shale. This is underlain by 315 feet of medium- to coarse-grained, argillaceous and dolomitic, arkosic sandstone. Farther to the south in the Imperial Cartridge F-72 well, the interval is comprised of gray to green siltstones and shales with minor quartzose sandstone at the top of the section. The Mazenod Member which will be discussed at a later point, is developed in the lower portion of the formation in the Imperial Windflower G-77 well. Below the Mazenod Member, many of the well cutting samples have been lost but the interval is probably represented by green waxy shale. Above the dolomite unit, the formation consists of interbedded siltstones and shales. The siltstones are quartzose, micaceous, glauconitic, dolomite and gray in color. The shales are green with some red coloring. Laminae of white anhydrite are common.

Nature of Contacts

The La Martre Falls Formation nonconformably overlies the Precambrian. The upper contact with the overlying Chedabucto Lake Formation is sharp but probably conformable. The top of the formation is picked above interbedded siltstones and shales below a dominantly dolomite unit which is locally sandy at the base.

Fossils and Age

No fossils have been collected from this unit in the subsurface. The following fauna was reported by Norris (1965, p. 20) from the top of the formation at the type section:

Diplograptus sp.

Ischadites sp.

bryozoans

worm borings

Desmograptus sp.

square crinoid stems

undet. echinoderms

Sowerbyella sp.

Lingulasma sp.

Hyolithes sp.

Sinuities sp.

Conularis sp.

orthoceraconic cephalopod

asaphid trilobite pygidium

calymenid trilobite

On the basis of this assemblage and the Late Ordovician age of the overlying Chedabucto Lake Formation, Norris (1965, p. 20) provisionally dated the La Martre Falls Formation as Middle Ordovician.

Correlation and Synonymy

The La Martre Falls Formation is interpreted as being equivalent to part of the Mirage Point Formation (discussed later) which is present to the south of the Snare Sill (see figs. 3 and 6).

The Red River Formation of Saskatchewan and Manitoba consists of a lower dolomitic limestone unit which comprises the main part of the formation and an upper rhythmic carbonate-anhydrite unit. The lower unit or Dog Head Formation (Baillie, 1952, p. 15) correlates physically and paleontologically with Middle Ordovician (Trentonian) rocks in the upper Mississippi Valley (Porter and Fuller, 1964, p. 42). Although the La Martre Falls and Dog Head Formations differ in lithology they lie in the same stratigraphic position and appear to be of the same age.

In the interior region of the Williston Basin, the basal beds of the Dog Head Formation, the Hecla Beds of Fuller (1961, p. 1345) are a calcareous, variably sandy and argillaceous unit that ranges up to 40 feet in thickness. This lower clastic unit contains glauconite which is missing in underlying Winnipeg Formation (Fuller and Porter, 1962, p. 477). The Hecla Beds yield a Middle Ordovician graptolite fauna (Fuller, 1961, p. 1,346) which has also been collected from the La Martre Falls Formation. The upper portion of the La Martre Falls Formation in Imperial Windflower G-77 well contains glauconitic siltstone. Richmond (1965, p. 280) reports glauconitic sandstone in outcrop from the La Martre Falls Formation. The presence of a Middle Ordovician graptolite fauna and the occurrences of glauconite further suggest a correlation between the La Martre Falls and Red River Formations.

Mazenod Member

The name Mazenod Member was proposed by Norris (1965) for a distinct dolomite unit which occurs in the lower part of the La Martre Falls Formation. The type section is a composite section compiled along an escarpment southwest of Mazenod Lake.

Distribution and Thickness

In outcrop, the Mazenod Member is discontinuously exposed in a narrow belt near and parallel to the Precambrian Shield (Norris, 1965, p. 20). It extends from north of Rivere la Martre northward to the southwest edge of Faber Lake. A complete section is not exposed at any one place, although it is estimated to be 70 feet or more in thickness. In subsurface, the unit is developed in the Imperial Windflower G-77 well where it attains a thickness of 65 feet.

Lithology

In outcrop, the Mazenod Member consists of gray nodular-bedded dolomite; conspicuous orange-brown weathering oolitic dolomite; and gray, medium-grained dolomite with interbeds of quartzose sandstone (Norris, 1965, p. 21). In the Imperial Windflower G-77 well, the Mazenod Member consists of gray to brown dolomite composed of finely crystalline rhombs with interbeds of dark gray to green shale in the upper portion.

Nature of Contacts

The Mazenod Member is overlain and underlain by siltstones and shales of the La Martre Falls Formation with transitional contacts.

Fossils and Age

No fossils have been collected from the unit in the subsurface. Norris (1965, p. 22) reported fucoidal markings in the upper part of the formation in outcrop. Its age is presumed to be Middle Ordovician.

Chedabucto Lake Formation

The name Chedabucto Lake Formation was proposed by Norris (1965) for a resistant dolomite unit which overlies the La Martre Falls Formation. The type section is composite and compiled from outcrops in the vicinity of Chedabucto Lake which is located just west of the North Arm of Great Slave Lake.

Distribution and Thickness

In outcrop, the Chedabucto Lake Formation appears as a lentil just south of Alexander Point which loses its identity to the south in the upper part of the Mirage Point Formation (Norris, 1965, p. 22, fig. 4). The formation thickens and becomes more prominent to the north. The thickness of the formation varies from zero just south of Alexander Point to an estimated 260 feet west of Faber Lake, where the outcrop belt reaches a maximum width of 26 miles. Norris (1965, pp. 25-26) reported a thinning of the unit to 50 feet in the area northward of Whitebeach Point to the north end of Great Slave Lake. Immediately north and south of this area, Norris reported thicknesses of 170 feet.

In this report which is concerned with the subsurface distribution of the formation, the Chedabucto Lake Formation is restricted to the area north of the Snare Sill where Norris noted thinning of the unit (see figs. 3 and 6). The formation is present in the three most northern wells, shown in cross-section A-A', namely, Imperial Lac Tache C-35, Imperial Cartridge F-72, and Imperial Windflower G-77. This southern limit corresponds to the area just north of La Martre Falls where Douglas and Norris (1959, p. 15) noted abrupt thickening of the formation from less than 100 feet to an

estimated 320 to 580 feet which is the location of the Snare Sill (see fig. 7). In subsurface, the formation thickens to the north with 275 feet of section in Imperial Windflower G-77 well, 383 feet in Imperial Cartridge F-72 well, and 483 feet in Imperial Lac Tache C-35 well.

Lithology

In outcrop, the Chedabucto Lake Formation consists of a thick-bedded to massive, highly resistant, scarp-forming, fine-grained, granular, in places minutely vuggy, medium brown dolomite (Norris, 1965, p. 22). This dolomite commonly weathers a pale orange or orange-brown in the south and a yellowish brown and gray to the north. Chert is present in the form of blebs and nodules in some beds. Purplish-red mottling is particularly prevalent in the southern portion, becoming less conspicuous north of La Martre Falls. The northern extent of this mottling corresponds with the area of abrupt thickening of the formation to the north as indicated by Douglas and Norris (1959, p. 15), the southern limit of the unit in the subsurface, and the location of the Snare Sill (see fig. 7). Richmond (1965, p. 283) listed the following lateral changes which suggest more restricted depositional conditions to the south:

1. Decrease with eventual disappearance of fossil and organic detritus to the south.
2. Increase in concentration of pyrite to the south.
3. Increase in concentration of anhydrite and gypsum to the south.

In Imperial Windflower G-77 well, the most southerly well in which the Chedabucto Lake Formation is recognized, the section consists of micro- to fine-grained, in places vuggy, tan to light brown dolomite. Pyrite is

present throughout the section which imparts an orange coloring from weathering on the dolomite along with blebs of anhydrite. At the base, the dolomite becomes shaly and sandy with interbeds of siltstone. In Imperial Cartridge B-72 well, the interval is comprised predominantly of micrograined, gray to brown dolomite with a trace of pyrite. The restricted environment migrated to the north at the end of Ordovician time as evidenced by the section in Imperial Lac Tache C-35 well. The upper 23 feet consists of cryptocrystalline, dolomitic, gray to brown anhydrite which overlies rhythmic deposits of cryptocrystalline, gray to brown dolomite with blebs of anhydrite alternating with micrograined, porous, gray to brown dolomite. The bottom half of the formation is micrograined, dark gray to brown dolomite which becomes sandy at the base.

Nature of Contacts

The lower contact of the Chedabucto Lake Formation with the La Martre Falls Formation is sharp but probably conformable. The base of the formation is picked at the top of the clastics below a predominantly dolomite unit which is sandy and argillaceous at the base. Locally, the Chedabucto Lake Formation non-conformably overlies the Precambrian (Norris, 1965, p. 22). The upper contact is unconformable with strata of Middle Devonian age. In the Imperial Windflower G-77 well, 15 feet of gray to green calcareous mudstone with blebs of anhydrite overlies the Chedabucto Lake dolomite. Ten feet of very fine- to fine-grained, quartzose sandstone with an argillaceous and dolomitic matrix unconformably overlies dolomite assigned to the Chedabucto Lake Formation in Imperial Cartridge B-72 well. Anhydrite assigned to the Chedabucto Lake Formation is unconformably overlain by 61 feet of aphanitic,

argillaceous and sandy, gray to green dolomite with interbeds of green, dolomitic shale in the Imperial Lac Tache C-35 well.

Fossils and Age

The following fossils were identified from the Chedabucto Lake Formation in the interval 3,160-3,185 feet in Imperial Triad Ebbutt D-50 well (62°19'01"N., 122°24'05"W.):

favositid coral
streptelasmid coral
stromatoporoids
brachiopod fragments
algae
worm borings

Halysitid corals were found from the Chedabucto Lake Formation in Shell Blackwater Lake G-52 well (64°01'20"N., 122°55'12"W) in the interval 4,801-4,835 feet.

Norris (1965, p. 26-27) reported the following fauna from the Chedabucto Lake Formation in outcrop:

<u>Stromatocerium</u> sp.	<u>"Syringopora"</u> sp.
<u>Bighornia</u> sp.	<u>Dinorthis columbia</u>
<u>Streptelasma</u> sp.	<u>Herbertella</u> sp.
angulate <u>Streptelasma</u>	<u>Lepidocyclas</u> sp.
small <u>Streptelasma</u>	<u>Leptaena</u> cf. <u>nitens</u>
Streptelasmid coral	<u>Leptaena?</u> sp.
<u>Calapoecia</u> sp.	<u>Rafinesquina</u> sp.
<u>Catenipora</u> sp.	<u>Rhynchotrema capax</u>

<u>Catenipora</u> sp. A	<u>Rhynchotrema</u> cf. <u>kananaskia</u>
indet. coral	large rhynchonelloid brachiopod
<u>Favistella</u> sp.	<u>Skenidioides</u> sp.
favositid coral	indet. brachiopods
<u>Foerstephyllum</u> sp.	indet. gastropods
<u>Paleofavosites</u> sp.	<u>Liospira</u> sp.
<u>Paleophyllum</u> sp.	<u>Lophospira</u> sp.
<u>Maclurites?</u> sp.	ophiuroids, fragmentary
<u>Sinuities</u> sp.	undet. echinoderms
orthoceraconic cephalopod	crinoid stems
<u>Bythocypris</u> sp.	undet. conodonts
<u>Ceraurus</u> sp.	
<u>Cybcloides</u> sp.	
<u>Caryocrinus</u> sp.	
<u>Cyclocystoides</u> sp.	
large <u>Glyptocystites</u>	

Most of the above fossils obtained from the Chedabucto Lake Formation in outcrop indicate a Late Ordovician (Richmond) Age (Norris, 1965, p. 26; Lord, 1939, pp. 12-13; 1942, pp. 36-38). On the basis of the fossils obtained in subsurface and correlation with the fossiliferous outcrop sections, the Chedabucto Lake Formation is dated as Upper Ordovician.

Correlation and Synonymy

The Chedabucto Lake Formation appears to grade laterally into the Mirage Point Formation to the south (Norris, 1965, p. 29, fig. 4) (see figs. 3 and 7). Norris (1965, p. 26) noted that some of the fossils from the Chedabucto Lake Formation have strong affinities with elements of the

Beaverfoot Formation of the Canadian Rocky Mountains, which is a crystalline dolomite. The formation probably correlates with the dolomites of the Mount Kindle Formation in the McConnell Range from which an Upper Ordovician (Richmond) fauna is reported by Douglas and Norris (1963, p. 11).

The Chedabucto Lake Formation appears to be equivalent to the Stony Mountain Formation of Saskatchewan and Manitoba. The Stony Mountain Formation consists of the lower Stony Mountain shale which is a series of fossiliferous argillaceous limestones and calcareous shales (Fuller and Porter, 1962, p. 479). The upper Stony Mountain or Gunton Beds are composed of mottled dolomitic fossiliferous fragmental limestone (Fuller and Porter, 1962, p. 480). The formation is dated as Upper Ordovician (Richmond) by Brindle (1960, p. 19).

Mirage Point Formation

The name Mirage Point Formation was proposed by Norris (1965) for a variable sequence of red beds which because of their relatively incompetent lithology are poorly exposed in outcrop. A type section was not defined although Norris (1965, p. 27) compiled a composite section from scattered outcrops along the south end of the west shore of the North Arm of Great Slave Lake between Alexander and Gypsum Points. The writer disagrees with Norris' (1965, p. 28) designation of the Mirage Point Formation in the subsurface. In outcrop, the Mirage Point Formation appears to be equivalent to the Middle and Upper Ordovician La Martre Falls and Chedabucto Lake Formations. In subsurface, the unit should not include the Lower Elk Point Evaporites (discussed later) of Middle Devonian age. The writer hereby proposes to amend the upper boundary of the formation in

the subsurface to include only the basal red beds which are comparable lithologically to the Mirage Point Formation in outcrop and are of probable Ordovician age. These red beds contrast sharply with the gray and brown colored Devonian strata.

Distribution and Thickness

In outcrop, only the upper part of the Mirage Point Formation is discontinuously exposed between Alexander and Gypsum Points along the south end of the west shore of the North Arm of Great Slave Lake (Norris, 1965, p. 27). The lower part is covered by water. The most complete outcrop section is on the northwest shore of Baker Bay where 30 feet of section is exposed. Norris (1965, p. 27) estimated a maximum thickness of 180 feet.

In this report, the Mirage Point Formation is applied to the red bed sequence developed south of the Snare Sill (see figs. 3 and 6). Norris divided the northern portion of these strata into the La Martre Falls and Chedabucto Lake Formations. In subsurface, the distinction cannot be made and the strata are grouped into the Mirage Point Formation. In subsurface, the Mirage Point Formation is recognized from the Imperial Triad Harris River F-71 well in the north to the Pyramid 202A drill hole located on the south shore of Great Slave Lake. The entire formation was cored in Pyramid 202A, Cominco G-1, and Cominco G-4 drill holes on the south shore of Great Slave Lake where the formation is 129, 99 and 131 feet thick respectively. Thicknesses of the Mirage Point Formation encountered in the wells included in cross-section A-A' west of Great Slave Lake are as follows:

Imperial Triad Harris River F-71 (33 feet)

Imperial Triad Willow Lake B-20 (80 feet)

Imperial Triad Davidson Creek P-2 (120 feet)

The formation was undoubtedly penetrated in the bottom part of Northwest Windy Point No. 1 well (61°19'N, 115°52'W). However, well samples and mechanical logs are not available for the well and the contacts and thickness of the formation cannot be determined.

Lithology

In outcrop, the Mirage Point Formation consists of a thinly interbedded sequence of dark dusky red, purplish and orange red dolomite, argillaceous dolomite, variably sandy dolomite, gypsiferous dolomite, dolomitic mudstone, variably sandy dolomite, very fine-grained dolomitic sandstone, green and red shale, gypsiferous shale, gypsum, and satin spar (Norris, 1965, p. 27). Mud cracks are present along some bedding planes and veinlets of secondary fibrous gypsum penetrate many beds of the exposed sequences.

In subsurface, the Mirage Point Formation is composed of a variable sequence of red dolomitic shale, green waxy shale, maroon dolomite which locally is sandy and argillaceous, red dolomitic mudstone with veinlets of anhydrite, and anhydrite. The section is capped by a thin persistent anhydrite bed except in the Pyramid 202A drill hole where a mudstone breccia is present at the top of the section. Angular fragments of gray to green dolomitic mudstone and anhydritic dolomite are in a matrix of green calcareous mudstone with flowage structures.

Nature of Contacts

The Mirage Point Formation appears to conformably overlies the Old Fort Island Formation which is predominantly a quartzose sandstone. Locally in the vicinity of basement highs, the formation nonconformably overlies the Precambrian.

The Mirage Point Formation is nonconformably overlain by rocks of Middle Devonian age. In outcrop, Richmond (1965, p. 287) noted a sharp contact between gray, vuggy dolomite assigned to the Middle Devonian Fitzgerald Formation and red, gypsiferous dolomite of the Mirage Point Formation near a scarp west of Alexander Point. In the subsurface immediately south of Great Slave Lake, a sharp contact is present between the Welleria meadowlakensis - bearing Fitzgerald Formation and anhydrite with breccia assigned to the Mirage Point Formation. North and west of Great Slave Lake, tan to brown dolomite and limestone of the Lower Elk Point Evaporites unconformably overlies a thin bed of anhydrite assigned to the Mirage Point Formation.

Fossils and Age

No fossils have been collected from this unit in the subsurface. In outcrop, Norris (1965, p. 26) reported sparse fossils found from opposite Rae Point southward to Alexander Point in red colored carbonates which he included in the Chedabucto Lake Formation.

In outcrop, the Mirage Point Formation occupies the same stratigraphic position in the south as do the combined La Martre Falls and Chedabucto Lake Formations to the north (Norris, 1965, p. 29). The two latter formations have been dated as Middle and Upper Ordovician on the basis of fossil evidence in outcrop.

If a stratigraphic section is drawn in the subsurface with the top of the Ordovician section as datum, the Mirage Point Formation is laterally equivalent to the upper part of the Chedabucto Lake Formation. If the section is drawn with the top of the Chinchaga Formation as datum, the formation is laterally equivalent to the lower part of the La Martre Falls Formation (see fig. 3). The unit has lithologies in common with both the La Martre Falls and Chedabucto Lake Formations but differs in its red color and evaporitic nature. The Chedabucto Lake Formation has been shown to become evaporitic to the south in both outcrop (Hume, 1920, pp. 33-34B; 1926, p. 60; Norris, 1965, pp. 22-23 and 26; Richmond, 1965, p. 283) and in the subsurface. The La Martre Falls Formation in outcrop has many lithologic similarities in common with the Mirage Point to the south. On the basis of the above evidence, the Mirage Point Formation is presumed to be Middle to Upper Ordovician in age.

Correlation and Synonymy

As used in the restricted sense, the Mirage Point Formation is synonymous with Cameron's (1917) "Redrock arenaceous limestone", Hume's (1921) "Red Beds", and the lower part of Cameron's (1922) "Red Beds". The Mirage Point Formation correlates with the La Martre Falls and Mirage Point Formations in subsurface and outcrop.

MIDDLE DEVONIAN

Middle Devonian rocks unconformably overlies Ordovician beds north, west, and immediately south of Great Slave Lake. They overstep the Precambrian basement of the Tathlina High and the Precambrian rocks

south of the Talston Upland. In northern Alberta, Devonian strata lie directly on Precambrian rocks.

A thin carbonate unit, the Fitzgerald Formation lies directly on Ordovician strata on the west shore of the North Arm of Great Slave Lake and in the subsurface immediately south of Great Slave Lake. The unit has not been recognized in the subsurface immediately west and north of Great Slave Lake. In northern Alberta, the Fitzgerald Formation overlies a granite wash unit, the La Loche Formation, which rests directly on the Precambrian. This is succeeded by a predominantly salt sequence which was deposited in three basins: the Lower Elk Point Basin and Bede Embayment where it is termed the Cold Lake Formation and the eastern Mackenzie Basin where it is informally designated as the Lower Elk Point Evaporites (see figs. 2 and 7). The overlying Chinchaga Formation extends over the entire map area and consists of two members. The Lower Member, developed only in the eastern Mackenzie Basin, consists mainly of anhydrite. The Upper Member which is a lateral gradation of limestone-dolomite-anhydrite going from north to south is present over the entire map area.

Rocks belonging to the Chinchaga and older Middle Devonian formations of the Great Slave Lake region in both outcrop and subsurface were first referred to as the Fitzgerald Formation (Cameron, 1917, 1922; Hume, 1920). The formation was interpreted to be Silurian in age because of the presence of a coral closely allied to the Silurian species Pycnostylus guelphensis and the occurrence of gypsum (Cameron, 1922, p. 19). These rocks were later examined by Norris (1963, 1965) who indicated a Middle Devonian age.

Because of the incompetent nature of this part of the section which is composed mainly of evaporites, only the basal more resistant

units are exposed in outcrop. The major part of the section has been studied in the subsurface. McGehee (1949) first described equivalent strata from three wells drilled in east-central Alberta. Workman (1953) and Law (1955) referred to this lower evaporite unit in northern Alberta. Sherwin (1962) subdivided the Lower Elk Point Subgroup in east-central Alberta and carried the units into northern Alberta. Belyea and Norris (1962) and Hunt (1954) adapted nomenclature for this lower section in northern Alberta and the southern Northwest Territories.

La Loche Formation

The name La Loche Formation was proposed by Norris (1963) for a sandstone that unconformably overlies the Precambrian and underlies the McLean Formation in the Clearwater-Athabasca Rivers area. The type section is at Contact Rapids on the Clearwater River. Norris (1963, p. 45) assigned the La Loche Formation to the sandstone, conglomerate, and weathered igneous detritus overlying the Precambrian and overlain by the Fitzgerald Formation along the Slave River. In this report, the La Loche Formation is used for the clastic unit in the subsurface of northern Alberta which is developed between the Precambrian and the Fitzgerald Formation. In the southern part of the map area, the formation is overlain by the Chinchaga and Contact Rapids Formations in the area of the Peace River Arch-Chipewyan Lakes Sill (see figs. 2 and 7). The term is restricted to the Bede Embayment and Chipewyan Lakes Sill of northern Alberta

Distribution and Thickness

The La Loche Formation was deposited mainly in the topographic lows on the Precambrian erosional surface.

Along the Slave River in northern Alberta the thickness of the formation varies from zero to 22.3 feet (Norris, 1963, p. 44). In the wells studied in northern Alberta, the thickness of the formation is variable ranging from zero in Pan American Whitesands No. A-1 well to 45 feet in Home et al. Fox Lake No. 4-30 well. The thicknesses of the formation in other wells included in cross-section C-C' are as follows:

Calstan Mikkwa River No. 12-23 (15 feet)

Home et al. Wood Buffalo No. 14-22 (12 feet)

Pan American Pitchimi Lake No. A-1 (35 feet)

Imperial Jack Lakes No. 8-17 (22.4 feet)

To the south, where the La Loche Formation is overlain by the Contact Rapids and Chinchaga Formations, the formation is much thicker attaining a maximum thickness of 98 feet in Bear Westmount No. 2 well (8-36-88-8W4th mer.).

Lithology

In outcrop along the Slave River, the basal beds of the La Loche Formation consist of a breccia of large angular fragments of granite (Norris, 1963, p. 45). This is transitionally overlain by an alternating sequence of very coarse-grained arkosic sandstone, conglomeratic sandstone, and interbeds of sandy mudstone. Near the top, the beds grade into fine- to coarse-grained sandy dolomite.

In subsurface, the La Loche Formation consists of a very fine- to very coarse-grained, usually red, arkosic sandstone at the base overlain by green to red, dolomitic shale and mudstone with blebs of anhydrite. In the wells in which Precambrian was probably topographically higher, shales and mudstone which are sandy at the base directly overlie the Precambrian. These

highs were subjected to more current and wave action resulting in the deposition of fine-grained clastics.

The basal part of the La Loche Formation appears to have been formed in situ by weathering of the Precambrian granite. The upward increase of sorting and carbonate content indicates the gradual advancement of marine conditions of deposition.

Nature of Contacts

The La Loche Formation nonconformably overlies the Precambrian. The base of the formation is picked at the point of contact between detritus and relatively unaltered basement.

In outcrop, the upper contact of the La Loche Formation with the overlying Fitzgerald Formation is gradational and arbitrary (Norris, 1963, p. 45). The beds grade from dolomitic sandstone to sandy dolomite. In subsurface, the upper contact is sharp but probably conformable between clastics and the overlying Fitzgerald dolomite.

Fossils and Age

No fossils have been collected from this unit either in surface or subsurface. The unit is limited above by the Fitzgerald Formation which has been dated as Middle Devonian (Eifelian) and below by the Precambrian. The upper contact of the formation with the overlying Fitzgerald Formation is gradational which suggests a continuous depositional sequence. On the basis of the above evidence, the La Loche Formation is dated as Middle Devonian in age in the map area. The unit is diachronous as it oversteps the Peace River Arch and Chipewyan Lakes Sill to the south. It is overlain by Middle to Upper Devonian rocks in an onlap relationship progressing toward

the arch.

Correlation and Synonymy

The La Loche Formation is synonymous with "Granite Wash" as used by Sproule (1956), Baillie (1956) and Greenwalt (1956) in the vicinity of the Peace River Arch. The term is also equivalent to Sherwin's (1962) Basal Red Beds at least in the vicinity of the Bede Embayment.

Fitzgerald Formation

Cameron (1918, p. 25) assigned the name "Fitzgerald dolomitic limestones" to the sequence of massive gypsum and dolomitic limestones exposed on the Peace and Slave Rivers and on the escarpment west of Fort Smith. On paleontological evidence, these beds were designated as Late Silurian in age. Using modern nomenclature, the formation would include evaporite beds from the Fort Vermilion Member of the Slave Point Formation to the Lower Elk Point Subgroup.

Cameron (1922, p. 14) summarized Kindle's report on the so-called Silurian fauna and gave a biostratigraphic definition for the Fitzgerald Formation:

"The Silurian fauna is represented by a single specimen of limestone showing a coral closely allied to if not identical with the well-known Guelph species Pycnostylus guelphensis. This specimen was collected from a point on the north shore of the lake about 5 miles west of Gypsum Point. The same fossil has been found by Kindle in dolomitic limestones overlying gypsum beds on the Peace River and outcrops of Paleozoic sediments on the Slave River above Fort Fitzgerald.

The beds which furnish this coral fauna have been named the Fitzgerald dolomites".

With the exception of the Peace River exposure, which is known to be late Middle Devonian in age, Richmond (1965, p. 294) has collected the coral Planetophyllum planetum Crickmay from all the localities designated as Silurian in age by Kindle (in Cameron, 1922, pp. 17-19). Because Planetophyllum planetum has been found at all the localities where the Upper Silurian coral Pycnostylus guelphensis was reported, they are undoubtedly the same organism.

The name Fitzgerald Formation is hereby restricted to the carbonate unit which underlies the Lower Elk Point evaporites and overlies the La Loche Formation along the Slave River and in the subsurface of the Bede Embayment and overlies the Ordovician Mirage Point Formation south and west of Great Slave Lake. This usage fits Cameron's (1922, p. 14) biostratigraphic definition and is essentially the same as that of Norris (1963, p. 48) in the Slave River area and of Richmond (1965, p. 294). The unit contains a well-developed coral fauna Planetophyllum planetum in the lower part of the unit and abundant individuals of the ostracode Welleria meadowlakensis in the upper part. The type area of the formation is designated as the exposures of the formation between Caribou and Stony Islands along the Slave River.

Distribution and Thickness

The Fitzgerald Formation is best exposed on the Stony and Caribou Islands along the Slave River where a maximum of 27 feet was measured. The top of the formation is not exposed in these outcrops. The formation is also well-developed in the vicinity of Chedabucto and Bras d'Or Lakes west

of the North Arm of Great Slave Lake (Richmond, 1965, p. 295).

In subsurface, the Fitzgerald Formation wedges out by onlap against the Peace River Arch to the south and can be mapped as far west as Kotcho Lake in northeast British Columbia. The unit can be traced as far north as the south shore of Great Slave Lake where it is completely cored in Pyramid 202A, Cominco G-1, and Cominco G-4 drill holes. The formation has not been delineated in the subsurface immediately west of Great Slave Lake. The limits of the recognizable Fitzgerald Formation are shown in Figure 2. The formation varies in thickness from zero along the margins of the Bede Embayment to over 50 feet. The thicknesses of the formation in wells included in cross-sections B-B' and C-C' are:

Cominco G-4 (43 feet)

Cominco G-1 (39 feet)

Pyramid 202A (41 feet)

Pan American Whitesands No. A-1 (33 feet)

Imperial Jack Lakes No. 8-17 (57.4 feet)

Pan American Pitchimi Lake No. A-1 (33 feet)

Home et al. Wood Buffalo No. 14-22 (33 feet)

Home et al. Fox Lake No. 4-30 (34 feet)

Calstan Mikkwa River No. 12-23 (24 feet)

This unit can be traced into the subsurface of the Lower Elk Point Basin of east-central Alberta and west-central Saskatchewan where it is called the Ernestina Lake Formation of Sherwin (1962) and Ostracod Limestone of Van Hees (1958) (see fig. 6).

Lithology

In outcrop along the Slave River, the Fitzgerald Formation

consists of slightly argillaceous, fine-grained, locally fragmental and fossiliferous, laminated to thick-bedded, medium to dark brown dolomite which is overlain by organic-rich conglomeratic dolomite (Richmond, 1965, p. 294). The conglomeratic dolomite is composed of reworked micritic doloarenite clasts and organisms (corals, brachiopods, gastropods, and ostracodes) in a poorly sorted doloarenite matrix.

In subsurface, the Fitzgerald Formation consists of a tan to dark brown, micrograined to microcrystalline, porous to tight dolomite with bituminous partings, local salt-filled porosity, and anhydrite interbeds. A thin unit of white to gray-brown, crypto- to microcrystalline anhydrite is often developed at the top.

Nature of Contacts

In the Slave River area, the Fitzgerald Formation overlies the La Loche Formation with a gradational contact. The base of the formation is placed at the top of the highest occurring sandstone. In the subsurface in northern Alberta, the lower contact with the La Loche Formation is sharp but probably conformable. In subsurface immediately south of Great Slave Lake and in outcrop immediately west of the North Arm of Great Slave Lake, the Fitzgerald Formation unconformably overlies red beds of the Ordovician Mirage Point Formation.

The formation is overlain conformably by the Cold Lake Formation. The upper contact is placed at the base of a red and green shale and mudstone unit above dolomite or anhydrite.

Fossils and Age

The Fitzgerald Formation carries a unique fauna which is

characterized by two species, the coral Planetophyllum planetum and the ostracode Welleria meadowlakensis, which are restricted to this basal Devonian carbonate unit. The coral Planetophyllum planetum is associated with a megafaunal and microfaunal assemblage and is found only in the lower part of the formation. As the Bede Embayment, Mackenzie Basin, and Lower Elk Point Basin became restricted, supersaline conditions were approached during which time most of the organisms were killed off. The only organism able to tolerate these conditions was the ostracode Welleria meadowlakensis which is restricted to the upper part of the formation. The two organisms have been found in the same section, but never in association with each other. Planetophyllum planetum along with an associated fauna is restricted to the lower part of the formation and Welleria meadowlakensis to the upper. Occurrences of these two organisms are listed in Tables 4 and 5.

Dr. J. P. A. Noble has identified the following fossils from the Fitzgerald Formation in the Slave River area and the subsurface of northern Alberta.

Planetophyllum planetum Crickmay

Camarotoechia sp.

Spinatrypa borealis Warren

Limoptera sp.

Amphipora sp.

dasycladid algae

The above assemblage is suggestive of a Middle Devonian age. Comparison of the ostracode fauna from the Fitzgerald Formation of the Slave River area with other Devonian faunas points toward an Eifelian Age (see Chapter Three).

TABLE 4

Occurrences of Planetophyllum planetum

1. Calstan Mikkwa River No. 12-23
12-23-98-21W4th mer.
3804-3830 feet.
2. Imperial Pan American Harper Creek No. 4-14
4-14-105-3W5th mer.
3. Caribou Island (R-35-60B)*
59°42'16"N. 111°31'16"W.
4. Unnamed Island (R-37-60B)*
59°39'20"N. 111°25'45"W.
5. Stony Islands (R-41-60B)*
49°35'19"N. 111°25'17"W.
6. Edgar Point (R-182-60B)*
61°51'35"N. 114°36'34"W.
7. R-124-60B*
62°22'16"N. 115°22'16"W.
8. R-129-60B*
62°21'28"N. 115°27'35"W.
9. R-125-60B*
62°21'44"N. 115°34'18"W.

* Reported by Richmond, 1965.

TABLE 5

Occurrences of Welleria meadowlakensis

1. Stanolind Rabbit Creek No. 15-10*
15-10-58-20W3rd mer.
2,580-2,660 feet.
2. Stanolind Whelan Creek No. 10-2*
10-2-59-24W3rd mer.
2,960 feet.
3. Imperial Bluebell No. 2-13*
2-13-60-20W3rd mer.
2,545 feet.
4. Saskatchewan Meadow Lake No. 4*
10-20-61-12W3rd mer.
1,790 feet.
5. Imperial Goodsoil No. 8-11*
8-11-62-22W3rd mer.
2,520-2,570 feet.
6. H.B. Beaver River No. 3*
16-18-68-12W3rd mer.
1,320 feet.
7. H.B. Beaver River No. 1*
1-21-71-11W3rd mer.
970 feet.
8. Can. Sbd. White Rose Elk Point No. 7-14*
7-14-57-6W4th mer.
3,830-3,853 feet.
9. Saskatchewan Tidewater Meadow Lake No. 4-34*
4-34-58-21W4th mer.
2,820-2,830 feet.
10. Cdn. Sbd. Ernestina Lake No. 10-13*
10-13-60-4W4th mer.
3,425-3,450 feet.

* Reported by Van Hees, personal communication.

TABLE 5 (contd.)

11. Imperial Grosmont No. 13-17*
13-17-67-23W4th mer.
5,530 feet.
12. Richfield Bohn Lake No. 15-29*
15-29-79-5W4th mer.
2,070-2,085 feet.
13. Imperial Pan American Harper Creek No. 4-14
14-14-105-3W5th mer.
14. Home et al. Wood Buffalo No. 14-22
14-22-110-1W5th mer.
2,380-2,385 feet.
15. Pan American Whitesands No. A-1
12-20-122-10W5th mer.
3,850-3,860 feet.
16. Pyramid 202A
60°47'42"N. 114°13'49"W.
976-981 feet.
17. Cominco G-4
60°54'N. 114°46'W.
18. Caribou Island
59°42'16"N. 111°31'16"W.
19. R-68-60B⁺
59°57'05"N. 111°44'25"W.

* Reported by Van Hees, personal communication.

+ Reported by Richmond, 1965.

Correlation and Synonymy

As defined, this map unit is synonymous with Norris' (1963, p. 48) Fitzgerald Formation. However, the exposures assigned to this formation and the associated fauna vary considerably. This basal dolomite unit is equivalent to Members 6 and 7 of the Elk Point Group of Crickmay (1954), the Ostracod Limestone of Van Hees (1958), and the Ernestina Lake Formation of Sherwin (1962).

Cold Lake Formation

The Cold Lake Formation was proposed by Sherwin (1962) for a predominantly salt section which occurs in the Lower Elk Point Subgroup. The type section for the formation is the interval between 2,663 and 2,832 feet in the White Rose C. and E. Cold Lake No. 7-22 well (7-22-66-1W4th mer.). In the type locality, the formation is overlain by the Contact Rapids Formation and underlain by the Ernestina Lake Formation. In this study, the Cold Lake Formation is used for the salt section which overlies the Fitzgerald Formation and underlies the Chinchaga Formation in the Bede Embayment in northern Alberta.

Distribution and Thickness

The Cold Lake Formation was deposited in two main evaporite basins, the Lower Elk Point Basin and the Bede Embayment. An equivalent evaporite section, informally termed the Lower Elk Point Evaporites, was deposited in the eastern Mackenzie Basin to the north. Beds assigned to the Cold Lake Formation have been described in the Bede Embayment of northern Alberta.

In the Bede Embayment, the Cold Lake Formation wedges out against

the Tathlina High and Talston Upland to the north, the Ft. Nelson High to the west, the Peace River Arch and Chipewyan Lakes Sill to the south, and the Precambrian Shield to the east (see figs. 5 and 6). The present limits of the formation are shown in Figure 2. There were two main centers of Cold Lake salt deposition in the Bede Embayment: the area immediately southwest of Wood Buffalo National Park in northeastern Alberta where the Cold Lake Formation attains a maximum thickness of over 270 feet and the Rainbow Lake-Zama Lake area in northwestern Alberta where the formation reaches a maximum thickness of about 200 feet. The thicknesses of the formation in wells included in cross-section C-C' in northern Alberta are as follows:

Calstan Mikkwa River No. 12-23 (38 feet)

Home et al. Fox Lake No. 4-30 (175 feet)

Home et al. Wood Buffalo No. 14-22 (194 feet)

Pan American Pitchimi Lake No. A-1 (260 feet)

Imperial Jack Lakes No. 8-17 (276 feet)

Pan American Whitesands No. A-1 (187 feet)

In the Lower Elk Point Basin to the south, a lower salt, the Lotsberg Formation, is developed below the Cold Lake and Ernestina Lake Formations. In this basin, the Cold Lake Formation only reaches a maximum thickness of 183 feet and covers a much smaller area than the Lotsberg Formation (Sherwin, 1962, p. 190).

Norris (1963, p. 308) reported that evaporite beds underlie a triangular wedge-shaped area west of the Slave River that intersects the river in the vicinity of La Butte and broadens northward to the Alberta-Northwest Territories boundary. The evaporites thin to a wedge at La Butte by a combination of non-deposition on the flanks of a Precambrian high and pre-Keg River erosion. The area is poorly drained and characterized by

numerous sink holes, salt pans, and springs which have been described by Camsell (1917). Norris (1965, p. 34) assigned these evaporites to the Chinchaga Formation. The writer believes that the lower part of these evaporites belong to the Cold Lake Formation while only the upper portion of the unit belongs to the Chinchaga Formation as defined later.

Lithology

In the wells studied in cross-section C-C', the Cold Lake Formation consists of a basal red dolomitic shale unit (6-23 feet) overlain by a massive salt section (18-270 feet). Core of the formation was examined from two wells: the interval 4,713-4,716 feet in Imperial Crossroads No. 15-32 well (15-32-109-19W5th mer.) and the interval 4,315-4,325 feet in the Imperial Surette Lake No. 15-24 well (15-24-109-17W5th mer.). In these cored intervals, the Cold Lake Formation consists of coarsely crystalline, clear halite. Red dolomitic mud is dispersed throughout the halite. The Cold Lake salt passes laterally into red dolomitic shales toward the margins of the Bede Embayment (Grayston, et al., 1964, p. 50). On the south shore of Great Slave Lake, the Cold Lake Formation is represented by a red mudstone breccia up to 51 feet thick which is present in the Pyramid 202A, Cominco G-1 and Cominco G-4 drill holes. The breccia consists of angular fragments of red dolomitic mudstone matrix.

Nature of Contacts

The lower contact of the Cold Lake Formation with Fitzgerald Formation is sharp, but probably conformable. The base of the formation is picked at the top of the dolomite or anhydrite below a thin red dolomitic shale unit which underlies a massive salt.

The Cold Lake Formation is disconformably overlain by the Chinchaga Formation. The upper contact is picked at the top of the massive salt section below a green to red, dolomitic shale unit. Locally a microcrystalline sandy, red dolomite is developed at base of the Chinchaga Formation.

Fossils and Age

No fossils have been collected from this unit. However, the Cold Lake Formation lies between the Chinchaga and Fitzgerald Formations which have been dated as Middle Devonian (Eifelian).

Correlation and Synonymy

The Cold Lake Formation is synonymous with Workman's (1953) Basal Variable Unit, Law's (1955) Red Beds, the lower part of Norris' (1963, 1965) "Evaporites" and Chinchaga Formation, the upper part of Hunt's (1954) Red Bed Series, and Beylea and Norris' (1962) Pre-Chinchaga Beds.

The formation is equivalent to Crickmay's (1954) Member No. 5 of the Elk Point Group and McGehee's (1949) Second Salt. The formation is correlative with at least part of the informally designated Lower Elk Point Evaporites in the Mackenzie Basin (discussed next).

Lower Elk Point Evaporites

The Lower Elk Point Evaporites is an informal term used to designate the strata between the Chinchaga and Mirage Point Formations west of Great Slave Lake in the eastern Mackenzie Basin. The beds occupy the same stratigraphic position and are probably the same age as the Lower

Elk Point subdivisions, Fitzgerald and Cold Lake Formations, in the Bede Embayment but cannot be differentiated in the subsurface west of Great Slave Lake.

Distribution and Thickness

The informally designated unit Lower Elk Point Evaporites is restricted to the eastern part of the Mackenzie Basin situated west of the North Arm of Great Slave Lake. Equivalent strata are present in the Bede Embayment and Lower Elk Point Basin to the south.

In the subsurface, the Lower Elk Point Evaporites occupy a wedge-shaped area which pinches out to the southeast between the Tathlina High and Precambrian Shield and broadens to the northwest (see fig. 2). The evaporites abutt abruptly to the northwest against the Snare Sill (see figs. 3 and 6). The thicknesses of the formation in wells included in cross-section A-A' are as follows:

Imperial Triad Davidson Creek P-2 (414 feet)

Imperial Triad Willow Lake B-20 (474 feet)

Imperial Triad Harris River F-71 (494 feet)

The unit was also penetrated in Northwest Windy Point No. 1 well (61°19'N., 115°52'W.) located on the northwest shore of Great Slave Lake as inferred from Cameron's (1922, p. 16) description. However, because the samples and mechanical logs are not available, the exact thickness of the unit cannot be determined.

Norris (1965, p. 32) mapped a belt of evaporites west of, and more or less parallel to, the North Arm of Great Slave Lake. This belt is characterized by playa lakes, sloughs, and relatively low, flat, plain-like areas. Norris (1965, p. 32) referred the evaporites in this belt to the

Chinchaga Formation. The lower part of these evaporites undoubtedly belongs to the Lower Elk Point Evaporites.

Lithology

Abundant gray and green shale was logged in the samples in the three wells in which the Lower Elk Point Evaporites were penetrated. This shale probably represents cavings from the shale beds at the top of the section. Lithology was determined by a combined sample and mechanical log control with core control where present.

The Lower Elk Point Evaporites consist of an upper massive salt section which attains a maximum thickness of 272 feet. The upper 20 feet of this section were examined in the Imperial Triad Davidson P-2 well. The interval consists of coarsely crystalline, clear halite with dispersed red mud and minor interbeds of anhydrite. The salt resembles that of the Cold Lake Formation and may be equivalent to that unit in the Bede Embayment. This massive salt unit is underlain by a thin red mudstone unit, a dolomite unit with minor anhydrite, and the second but much thinner salt-anhydrite unit which reaches a maximum thickness of 90 feet. A carbonate unit up to 60 feet in thickness is developed at the base of the unit. This interval was partially cored in Imperial Triad Willow Lake B-20 well and consists of a microcrystalline, salty, light to dark brown, mottled limestone which becomes green in color and shaly toward base. This unit may be correlative with the Fitzgerald Formation which outcrops in the area of Chedabucto and Bras d'Or Lakes to the west of the North Arm of Great Slave Lake and is developed in the subsurface immediately south of Great Slave Lake.

Nature of Contacts

The Lower Elk Point Evaporites rest unconformably on the Mirage Point Formation of Ordovician age. The basal contact is arbitrarily picked at the base of the carbonate unit which may be the Fitzgerald Formation equivalent above a thin anhydrite unit which is underlain by red beds. In outcrop, light gray dolomite assigned to the Fitzgerald Formation which is argillaceous and locally silty at the base is in sharp contact with red, gypsiferous dolomite of the Mirage Point Formation on a scarp west of Alexander Point (Richmond, 1965, p. 287).

The contact of the Lower Elk Point Evaporites with the overlying Chinchaga Formation is sharp and may be disconformable. The top of the unit is picked at the top of a massive salt section below a thin red mudstone or green shale unit. In the Imperial Triad Davidson Creek P-2 well, a red dolomitic mudstone breccia immediately overlies the salt.

Fossils and Age

Ostracodes assigned to the Middle Devonian Eifelian Stage have been collected from the basal limestone unit of the Lower Elk Point Evaporites in the Imperial Triad Willow Lake B-20 well in the interval 3,000 to 3,019 feet. The evaporites are limited above by the Chinchaga Formation which is tentatively dated as Middle Devonian (Eifelian) in age. On this basis, the entire Lower Elk Point Evaporites are placed in the Middle Devonian Eifelian Stage.

Correlation and Synonymy

The Lower Elk Point Evaporites are synonymous with the upper part of the Red Beds as described by Cameron (1922) and Hume (1932) and

the upper part of the Mirage Point as picked in the subsurface by Belyea and Norris (1962) and Norris (1965).

The evaporites are equivalent to the combined Fitzgerald-Cold Lake Formations interval in the Bede Embayment of northern Alberta.

Chinchaga Formation

The name Chinchaga Formation was proposed by Law (1955) for a predominantly anhydrite unit with minor dolomite in the subsurface of northwestern Alberta. The type section for the formation is the interval 5,475 to 5,680 feet in the California Standard Steen River No. 2-22 well (2-22-117-5W6th mer.). The lower boundary has been adjusted downward from that of Law's to include a lower detrital unit (see Grayston, et al., 1964, fig. 3). In this study, the Chinchaga Formation includes the unit as originally defined by Law (1955) plus a lower evaporitic unit which is developed north and west of the type section. The original unit plus a thin detrital unit is informally designated as the Upper Member, while the lower evaporitic unit is termed the Lower Member. This two-fold subdivision is essentially the same as that used by Belyea and Norris (1962).

Distribution and Thickness

The Chinchaga Formation extends in the subsurface over the entire map area except in the extreme southern portion where the formation grades laterally into the Contact Rapids Formation in the area of the Chipewyan Lakes Sill (see figs. 5 and 6). In the Bede Embayment, where only the upper member is developed, the formation varies in thickness from zero, where the Keg River Formation oversteps onto the Peace River Arch, to over 200 feet. The thicknesses of the formation included in cross-section C-C' in northern

Alberta are:

Calstan Mikkwa River No. 12-23 (24 feet)

Home et al. Fox Lake No. 4-30 (179 feet)

Home et al. Wood Buffalo No. 14-22 (174 feet)

Pan American Pitchimi Lake No. A-1 (206 feet)

Imperial Jack Lakes No. 8-17 (209 feet)

Pan American Whitesands No. A-1 (235 feet)

The Chinchaga Formation is considerably thicker in the Mackenzie Basin where both the Lower and Upper Members are developed, attaining a maximum thickness of 728 in the Imperial Cartridge B-72 well. The formation thins rapidly and in places is absent over the Tathlina High. The south shore of Great Slave Lake marks the most southerly development of the Lower Member. Here the Chinchaga Formation is 337, 297, and 315.5 feet thick in the Pyramid 202A, Cominco G-1, and Cominco G-4 drill holes respectively. The formation thickens to the north and west attaining the following thicknesses in wells included in cross-section A-A'.

Imperial Triad Davidson Creek P-2 (279.3 feet)

Imperial Triad Willow Lake B-20 (331 feet)

Imperial Triad Harris River F-71 (523 feet)

Imperial Windflower G-77 (550 feet)

Imperial Cartridge B-72 (728 feet)

Imperial Lac Tache C-35 (472 feet)

In the Northwest Windy Point No. 1 well (61°19'N, 115°52'W), 275 feet of the Chinchaga Formation were encountered (see Cameron, 1922, p. 16).

Norris (1965, p. 32) reported evaporites underlying a belt west of, and more or less parallel to, the North Arm of Great Slave Lake and a triangular-shaped area between the Slave River and an extension of the Salt

River escarpment in northern Alberta. Norris (1965, p. 32) included all of these rocks in the Chinchaga Formation. The evaporites probably include evaporites from both the Chinchaga and Cold Lake Formations and equivalents.

Lithology

In the Bede Embayment where only the Upper Member is present, the Chinchaga Formation consists of tan to light brown, cryptocrystalline anhydrite with minor interbeds of tan to medium brown, very finely crystalline dolomite. Near the base, the anhydrite becomes argillaceous and contains minor beds of light green, calcareous shale. A thin clastic unit up to 64 feet in thickness is present at the base of the formation. This clastic unit is composed of green calcareous shale which becomes red in color and dolomitic toward the base with minor red microcrystalline dolomite.

To the south, the Chinchaga Formation thins over the Chipewyan Lakes Sill and passes laterally into the Contact Rapids Formation, a dolomite-clastic sequence (see figs. 5 and 6). In the Calstan Mikkwa River No. 12-23 well, 24 feet of anhydrite belonging to the Chinchaga Formation overlies 110 feet of predominantly green shale assigned to the Contact Rapids Formation.

Immediately south of Great Slave Lake, the Chinchaga Formation has been completely cored in Pyramid 202A, Cominco G-1, and Cominco G-4 drill holes. The formation here consists of white to light brown, cryptocrystalline anhydrite with interbeds of micro- to medium-grained, light brown, anhydritic dolomite. Thin beds of green calcareous mudstone are developed in the lower part of the section, especially in the interval 130 to 160 feet below the top of the Chinchaga Formation. This interval is picked as the detrital unit which subdivides the formation in two members. Many of the anhydrite beds are highly contorted and often have angular fragments

of mudstone incorporated within them suggesting flowage of the anhydrite.

To the north in the Imperial Davidson Creek P-2 well, the Upper Member consists of a basal 15 foot mudstone unit overlain by interbedded dolomite and anhydrite. The basal "detrital unit", which has a characteristic mechanical log deflection, is used as the marker which subdivides the formation into two informally designated members in this area. To the north and west, the Upper Member loses its evaporitic character. In the other wells included in cross-section A-A', the lithology of the Upper Member is predominantly limestone and dolomite. The upper portion becomes lithologically continuous with the overlying Lonely Bay Formation and the pick for the upper contact is determined by mechanical log markers. There is thus a lateral facies gradation in the Upper Member going from normal marine carbonates in the north to evaporites in the south in the Bede Embayment.

The Lower Member consists of a thin detrital unit of shale, mudstone, and sandstone overlain by predominantly anhydrite with some dolomite. North of the Snare Sill, the Lower Member thickens and the basal portion is equivalent to the Lower Elk Point Evaporites to the South.

Nature of Contacts

The Chinchaga Formation unconformably overlies the Upper Ordovician Chedabucto Lake Formation in the northern part of the map area. In the southern Mackenzie Basin, where the Chinchaga Formation overlies the Lower Elk Point Evaporites, the contact is sharp and may be disconformable. To the south, in the Bede Embayment, the contact with the underlying Cold Lake Formation is interpreted to be disconformable. This interpretation is based

on the fact that emergent conditions must have existed in the Bede Embayment at the time of deposition of the Lower Member in the Mackenzie Basin.

The contact with the overlying Keg River Formation is sharp but probably conformable in the Bede Embayment. The upper contact of the Chinchaga Formation is placed at the base of the limestone or dolomite unit above anhydrite. In the southern Mackenzie Basin, the upper contact of the Chinchaga Formation is gradational and picked at the highest occurrence of anhydrite below carbonates of the Lonely Bay Formation. To the west and north, the upper contact is arbitrary and is picked on the mechanical logs. In the Imperial Lac Tache C-35 well, the Chinchaga Formation is unconformably overlain by Cretaceous shales.

Fossils and Age

Tentaculitids have been collected from the lower detrital unit of the Chinchaga Formation in the intervals 3,584-3,590 and 3,620-3,630 feet in Pan American Whitesands No. A-1 well. Ostracodes dated as Devonian in age have been collected from the Lower Member in Imperial Cartridge B-72 well. No other fossils have been found in the subsurface of this evaporitic formation.

Norris (1965, p. 36) reported a poorly preserved fauna of ?Spinatrypa sp. cf. ?S. andersonensis and ?Anatrypa sp. from a dolomite unit near the middle of the formation on the south side of Great Slave Lake. Norris suggests a possible Eifelian Age for this part of the formation on the basis of the presence of ?Anatrypa sp.

The lower Hume Formation of the lower Mackenzie valley is interpreted to be laterally equivalent to the Upper Member of the Chinchaga Formation. The lower Hume contains a rich brachiopod-coral fauna which has

been dated as Eifelian (Warren and Stelck, 1962, p. 277; McLaren, 1962, p. 12; Crickmay, 1966, p. 38).

The Chinchaga Formation is overlain in the northern part of the map-area by the fossiliferous Lonely Bay Formation. Norris (1965, p. 36) has dated this formation as early Givetian. On the basis of the above evidence, the Chinchaga Formation is tentatively dated as Eifelian in age.

Correlation and Synonymy

The Chinchaga Formation is equivalent to the interval assigned to the Fitzgerald Formation in the Imperial Windy Point No. 1 well (61°19'N., 115°52'W.) by Cameron (1922, p. 16). It is synonymous with Campbell's (1957) and Hunt's (1954) Fitzgerald Formation and Workman's (1953) Lower Anhydrite and Dolomite Unit.

To the west and north of the map-area, the Bear Rock Formation occupies the same stratigraphic position as the Lower Member of the Chinchaga Formation and the older Lower Elk Point Evaporites. The "detrital unit" which is used to subdivide the formation into two members is interpreted to be equivalent to the thin shale bed which locally separates the Bear Rock Formation from the overlying Hume Formation (Bassett, 1961, p. 484). The lower part of the Hume Formation is then laterally equivalent to the Upper Member of the Chinchaga Formation.

The Chinchaga Formation correlates with Belyea's (1952) Dense Dolomite Unit, the lower part of Crickmay's (1954) Member No. 3 and Member No. 4 of the Elk Point Formation, part of 'Van Hees' (1956, 1958) Meadow Lake Beds, and Sherwin's (1962) Contact Rapids Formation in the Lower Elk Point Basin.

The Ashern Formation, a regolithic soil unit developed on the

Siluro-Ordovician cuesta to the south, has been correlated with various parts of the Elk Point Formation (Crickmay, 1954; Van Hees, 1956, 1958; Walker 1957; Buller, 1958; Carrigy, 1959; Kesling and Takagi, 1961; and Sherwin, 1962). The writer agrees with Sherwin (1962, p. 190) in that the term Ashern should be restricted to the thin reworked regolithic unit developed on the Siluro-Ordovician cuesta developed in southern Alberta and Saskatchewan. The Chinchaga Formation represents a restricted to normal marine sequence most of which was deposited while the Siluro-Ordovician cuesta was still emergent.

CHAPTER THREE

OSTRACODES FROM THE FITZGERALD FORMATION, SLAVE RIVER AREA, ALBERTA

Definition of Unit

The name Fitzgerald Formation is restricted to the carbonate unit which underlies the evaporite sequence and overlies the La Loche Formation along the Slave River. This usage, which is essentially the same as that of Norris (1963, p. 48) and Richmond (1965, p. 294), fits Cameron's (1922, p. 14) biostratigraphic definition (see pages 31-32). The unit contains a well-developed coral fauna, Planetophyllum planetum, with an associated megafauna and microfauna in the lower part of the formation and a restricted fauna of only one species, the ostracode Welleria meadowlakensis, in the upper part of the formation. The type area is the exposures of the formation between Caribou and Stony Islands on the Slave River.

Fossils and Age

The Fitzgerald Formation is the basal carbonate unit of the Lower Elk Point Subgroup in northern Alberta which is composed predominantly of evaporites. Opinions have varied as to the age of the Lower Elk Point Subgroup because of lack of paleontological evidence. Cameron (1922, p. 19) dated the Fitzgerald Formation which included the basal carbonate unit and the overlying evaporites as Late Silurian. This age was determined on the presence of a coral closely allied to the Silurian species Pycnostylus guelphensis, which now is identified as Planetophyllum planetum, and the occurrence of gypsum. McGehee (1949, p. 613) assigned a Silurian age to the sequence on the basis of its stratigraphic relationship to rocks defined as Silurian in outcrop. Crickmay (1954, p. 157) inferred that the Elk Point

Group represented one "lithogenetic episode" and since Middle Devonian fossils were collected from the upper part of the group, he suggested a Middle Devonian age for the entire Elk Point Group. Walker (1957, p. 58) correlated the red colored carbonates near the top of the Red River Formation with the red silts of the Lower Elk Point Subgroup and assigned the latter to the Ordovician. Van Hees (1958, p. 76) considered the Lower Elk Point to belong in the Onesquethaw Stage of the Ulsterian Series on the presence of the Welleria fauna. This stage is Coblenzian or Lower Devonian in European classification, but interpreted as Middle or Lower Devonian in American classifications (Van Hees, 1958, p. 76). Buller (1958, p. 49) considered the Lower Elk Point Subgroup to be Middle Devonian because it represented a continuous depositional cycle with the Upper Elk Point which is definitely dated as Middle Devonian.

The following fauna, identified by Dr. J. P. A. Noble of Pan American Petroleum Corporation, has been collected from the Fitzgerald Formation in the Slave River area:

Spinatrypa borealis Warren

Planetophyllum planetum Crickmay

Limoptera sp.

Camarotoechia sp.

Amphipora sp.

Dascycladid algae

Ostracodes (to be described hereunder)

The fossils noted above, especially Amphipora sp., are more indicative of a Devonian rather than an Ordovician or Silurian age. However, a more precise age determination cannot be made. The ostracode fauna from the Fitzgerald Formation in the Slave River area was compared with similar faunas

elsewhere in an attempt to obtain a more precise age for the Fitzgerald Formation and the Lower Elk Point Subgroup.

Comparison of the ostracode fauna from the Fitzgerald Formation with other Devonian faunas from Bashkiria and the southern Urals, U.S.S.R. and eastern United States suggest an Eifelian Age. This age is determined by ostracode species which occur in both Alberta and the U.S.S.R. or eastern United States. Further evidence is supported by ostracode species from the Fitzgerald Formation which show close affinities to similar species from the U.S.S.R., eastern United States, and western Canada.

In the first grouping, both Rozhdestvenskayites auriculiferous (Rozhdestvenskaya) McGill and Rectobairdia lacunosa (Rozhdestvenskaya) n. comb. have been described from the Eifelian of the U.S.S.R. Rozhdestvenskayites auriculiferous occurs in the Calceolocian beds of Eifelian Age. Rectobairdia lacunosa was recorded from the "Lower Limestone" of the Eifelian Biya beds. It is important to note that all described species of Baschkirina Rozhdestvenskay have been restricted to the Eifelian deposits of the U.S.S.R. Rishona epicypha (Kesling and Kilgore) Sohn and Acanthoscapha devonica (Kesling and Sohn) n. comb. which occur in the Fitzgerald Formation, were originally found in the Genshaw Formation and Centerville Member of the Ludlowville Shale respectively of eastern United States which are interpreted to be Eifelian in age. Smith (1956, p. 1) reported that the lower Ludlowville shales contain a fauna characteristic of the Marcellus Shale. Cooper (1942, p. 1,732) places the Marcellus Shale in the Eifelian on Paleontological evidence.* The Genshaw Formation and Centerville Member of the Ludlowville Formation are stratigraphically lower than the Marcellus fauna and thus are Eifelian in age. Evlanella joussardensis McGill, which is found in both the middle and upper Givetian rocks of western Canada and the Fitzgerald Formation, is

*G. Klapper, personal communication, reports Eifelian conodonts from the Marcellus Formation.

believed to be a long ranging species.

Closely related Russian and Albertan species include Paraparchites sp. cf. P. dedaleus (Rozhdestvenskaya) McGill, Baschkirina sp. cf. B. memorabis Rozhdestvenskaya, and ?Pseudobythocypris praepilatus (Polenova) McGill. Paraparchites dedaleus was first described from the "Middle Limestone" of early Givetian Age in the U.S.S.R. Specimens comparable to P. dedaleus were described by McGill from the middle Givetian Kee Scarp Formation of the Northwest Territories. Rozhdestvenskaya reported his specimens of Baschkirina memorabis from the Eifelian Biya beds. Pseudobythocypris praepilatus was first reported by Polenova from the lower Eifelian of the Kuznetz Basin and later reported by McGill from the middle Givetian Kee Scarp Formation. A specimen similar to Acanthoscapha navicula (Ulrich) Berdan from the Helderberg beds (Lower Devonian) of New York was obtained from the Fitzgerald Formation.

Correlation by species indicates an Eifelian Age. Comparison of related species suggests an age spread from Early Devonian to middle Givetian. The above age appraisal points to an Eifelian Age for the Fitzgerald Formation, although the evidence is not directly related to the type Eifelian.

Paleogeography and Paleoecology

The Slave River area represents the "wedge-edge" of the Lower Elk Point Subgroup against a Precambrian high. The early Middle Devonian sea advanced from the northwest to the south over the irregular Precambrian unconformity in northern Alberta. A basal reworked detrital unit of granitic derivation and composition, the La Loche Formation, was deposited in the topographically low areas on the Precambrian basement. This detrital unit is conformably overlain by the locally fossiliferous Fitzgerald Formation which represents a near shore, shallow water deposit of the transgressing

sea. This unit, which by nature of its origin must be variable in age, has been traced into the subsurface of northern Alberta.

The presence of a distinct coral, Planetophyllum planetum, which is found in the lower part of the Fitzgerald Formation near Precambrian highs supports the conclusion that the unit represents a near shore, shallow water deposit. The ostracodes described hereunder are associated with Planetophyllum planetum except for Welleria meadowlakensis. As the Bede Embayment (see fig. 7) became restricted, supersaline conditions were approached during which time most of the organisms were killed off. The supersaline conditions are evidenced by the presence of a restricted fauna of one species, the ostracode Welleria meadowlakensis. Kesling and Takagi (1961, p. 35) suggested that the ostracode Welleria meadowlakensis from equivalent beds in Saskatchewan probably lived near the channels which supplied the basin with normal marine water. The Fitzgerald Formation is overlain by Lower Elk Point evaporites (salt and anhydrite) which represent a more restricted stage in the evaporite cycle.

The evaporite deposition was followed by a major flooding in Givetian time which resulted in the extension carbonate deposition of the Keg River, Winnipegosis, Methy, Lonely Bay, Pine Point, and Little Buffalo Falls Formations. This transgression which marks the start of the Upper Elk Point Subgroup was much more extensive than that of the Lower Elk Point. The basal carbonate unit onlaps the older Lower Elk Point Subgroup and rests directly on Precambrian rocks in places.

Description of Collecting Localities (after Richmond, 1965)

Station: R-35-60-B (59°42'16"N., 111°31'16"W.)

Six feet of the Fitzgerald Formation are exposed on an isolated

outcrop located at the top of a cliff on the south end of Caribou Island. The outcrop consists of a light brown conglomeratic dolomite. The dolomite is composed of reworked micritic doloarenite clasts, corals, brachiopods, gastropods, and ostracodes in a coarse- to fine-grained doloarenite matrix. Along the south shore of the island, 27 feet of dolomite and limestone assigned to the Fitzgerald Formation overlie 23 feet of the La Loche Formation. The isolated outcrop correlates with the middle portion of an exposure along the south shore. Since the original work was done by Richmond in the summer of 1960, the writer along with Drs. W.O. Richmond and J.P.A. Noble have found Welleria meadowlakensis in the upper three feet of the exposures on the south shore of the island. The occurrence of Welleria meadowlakensis indicates that this upper portion is close to the top of the formation.

Station: R-68-60B (59°57'05"N., 111°44'25"W.)

On the Slave River between Fort Fitzgerald and Fort Smith, a light brown microcrystalline gypsum conformably overlies brown dolomite. The dolomite is underlain by light brown, micritic, skeletal limestone and dolomite. This carbonate unit is interpreted by the writer to be the top of the Fitzgerald Formation because of the presence of the ostracode Welleria meadowlakensis.

Formal Descriptions of Ostracodes

A total of 13 genera and 16 species of ostracodes are described and illustrated from the Fitzgerald Formation of the Slave River area.

Specimen abundance for the most part is very low and in the cases of Acanthoscapha navicula and Rishona epicypa, only one representative of the species was found. Specimens of Rozhdestvenskayites auriculiferous and Microcheilinella sp. are abundant. At station R-68-60B, the dolomite is a

"coquina" composed almost entirely of carapaces of Welleria meadowlakensis.

The ostracodes from the Fitzgerald Formation have been dolomitized. Standard micropaleontological techniques, such as crushing, were usually unsuccessful in releasing the ostracodes from the matrix. An acid disintegration method was found to be most successful.

Samples were crushed to fragments less than one inch in diameter. 200 to 400 grams were added to 10% acetic acid for 8-10 hours (time element is crucial). The residue was gently washed through sieves, dried, and examined for microfossils.

Because of dolomitization, details of structure and ornamentation were often obscured and difficult to evaluate. An ammonium chloride coating on the ostracodes aided in both identification and photography.

All figured and unfigured specimens have been placed in the ostracode collection at Pan American Petroleum Corporation, Calgary, Alberta.

Family BETRICHIIDAE Matthew, 1886

Genus WELLERIA Ulrich and Bassler, 1923

Welleria meadowlakensis Kesling and Takagi

Plate II, figures 1-6

Synonymy

Welleria meadowlakensis Kesling and Takagi, 1961, Michigan Univ. Mus. Paleont. Contrib., v. 17, no. 1, pp. 43-47, pl. 3, figs. 1-10, pl. 4, figs. 1-16, pl. 5, figs. 1-8.

Welleria sp. Buller, 1958, Oil in Canada, v. 10, no. 23, p. 44.

Welleria sp. Van Hees, 1958, Sec. Internat. Williston Basin Sympos., p. 74, figs. 9-10.

Description of male

Carapace subelliptical in lateral view. Left valve overlaps right valve along free margin. Straight hinge line. Anterodorsal and posterodorsal borders nearly straight, anteroventral and posteroventral borders rounded, and ventral margin slightly curved.

Lateral surface divided by two dorsal sulci which divide each valve into three unequal lobes. L1 very low, separated from L2 by shallow groove S1. L2, same width as L1, more pronounced and below hinge line. L3 is large, extends over hinge line and separated from S2 which is deeper and more distinct than S1. Elongate ventral lobe which is continuous with the dorsal lobes.

Low velate ridge extends along free margin of each valve. Submarginal ridge in left valve which presumably is overlapped in right valve.

Greatest height central, greatest width through L3. Surface smooth.

Description of female

All features like those of male except for elongate brood pouch which extends ventrally below free edge.

Dimensions of figured specimens

Adult male: Length 1.25 mm., height 0.84 mm., width 0.82 mm.

Adult female: Length 1.30 mm., height 0.91 mm., width 0.95 mm.

Remarks

Welleria meadowlakensis appears to be restricted to and represents the only species occurring in the upper part of the carbonate unit that underlies the Lower Elk Point evaporites.

Age equivalence

On stratigraphic position, Kesling and Takagi (1961, p. 41) correlated the Meadow Lake beds from which Welleria meadowlakensis was originally found with the Detroit River Group of Michigan. The Detroit River Group is placed in the Onesquethaw Stage of the Ulsterian Series (Lower Devonian).

Occurrence

On Caribou Island and on Slave River between Fort Fitzgerald and Fort Smith.

Family ROZHDESTVENSKAYITIDAE McGill, 1966

Genus ROZHDESTVENSKAYITES McGill, 1966

Rozhdestvenskayites auriculiferous (Rozhdestvenskaya)

McGill

Plate III, figures 1-3

Synonymy

Aparchites auriculiferous Rozhdestvenskaya, 1962, U.S.S.R. Acad. Sci., pp. 171-172, pl. 1, figs. 1-2.

Description

Carapace inequivalved, large, subcircular, and dorsally truncated in lateral view. Carapace compressed in dorsal view. Hinge line straight with slight auricular projections at each cardinal angle. Greatest height slightly anterior, greatest width central. Surface smooth.

Dimensions of figured specimen

Length 1.74 mm., height 1.32 mm., width 0.94 mm., hinge line 1.22 mm.

Remarks

Shell is similar to R. diuturna McGill from Slave Point Formation of late Givetian Age. However, R. diuturna is smaller in size and has a reticulate surface with a smooth muscle spot.

Age equivalence

R. auriculiferous was described from the Calceolovian beds of Eifelian Age by Rozhdestvenskaya.

Occurrence

Caribou Island.

Family KLOEDENELLIDAE Ulrich and Bassler, 1908

?Genus EUKLOEDENELIA Ulrich and Bassler, 1923

Eukloedenella? sp.

Plate III, figures 4-6

Description

Carapace subquadrate in lateral view. Right valve slightly larger than left valve; overlap not apparent. Dorsal border straight, anterior and posterior borders broadly rounded, and ventral border gently convex. Hinge line straight incised in posterior portion. Short, distinct, anterodorsal sulcus which divides each valve into two unequal lobes. L1 without expression and L2 inflated; highly convex posteroventral lobe continuous with L2. Greatest convexity ventral, greatest height anterior to sulcus, and greatest width posterior.

Dimensions of figured specimen

Length 0.54 mm., height 0.34 mm., width 0.34 mm.

Remarks

Two poorly preserved specimens are tentatively assigned to Eukloedenella Ulrich and Bassler because of the presence of an anterodorsal sulcus in each valve.

Occurrence

Caribou Island.

Family LICHVINIIDAE Posner in Egorov, 1950

Genus EVLANELLA Egorov, 1950

Evlanella joussardensis McGill

Plate III, figures 7-10

Synonymy

Evlanella joussardensis McGill, 1966, Bull. Can. Petrol. Geol., v. 4, p. 117, pl. 3, figs. 10-14.

Evlanella joussardensis McGill, 1967, Internat. Dev. Sympos. Proceed.,

in press.

Description

Carapace oval, equivalved, and dorsally truncated by long straight hinge line. Marginal ridge extends along free margin in each valve from anterodorsal to posterodorsal portions of the carapace, very close to free margin along anterior and ventral margins. Lateral surface characterized by pit, located anterodorsal to midpoint; closer to dorsal border of left valve. L2 projects into pit and terminates in a node; L2 equally divides pit in right valve, but lies in anterior portion in left valve. L1 and L3 are subdued. Greatest height anterior, greatest width central with sub-parallel valves in ventral view.

Dimensions of figured specimen

Length 0.99 mm., height 0.62 mm., width 0.45 mm.

Age equivalence

E. joussardensis has been described from middle and late Givetian beds in western Canada by McGill. This species is interpreted to be long ranging.

Occurrence

Caribou Island.

Family PARAPARCHITIDAE Scott, 1959

Genus PARAPARCHITES Ulrich and Bassler, 1906

Paraparchites sp. cf. P. dedaleus (Rozhdestvenskaya) McGill

Plate III, figures 11-13.

Synonymy

Punctaparchites? dedaleus Rozhdestvenskaya, 1959, U.S.S.R. Acad. Sci., Bashkirian Div., pp. 29-30, pl. 2, fig. 1.

Paraparchites dedaleus McGill, 1967, Internat. Dev. Sympos. Proceed., in press.

Description

Carapace subovate, equivalved. Hinge line straight and channeled. Pronounced forward swing of anterior end. Anterior cardinal angle without definition, posterior cardinal angle distinct with slight auricular projection. Carapace thickens along free margin of each valve to form ridge-like structure. Greatest height central, greatest width posterior with tapering toward anterior. Surface punctate in well-preserved specimen with smooth, circular, centrally-located muscle scar.

Dimensions of figured specimen

Length 0.58 mm., height 0.48 mm., width 0.36 mm.

Remarks

The specimens from Caribou Island are similar to specimens of P. dedaleus collected by Rozhdestvenskaya. They differ in their lack of definition of the anterior cardinal angle. These specimens are also comparable to McGill's specimens by the presence of a distinct posterior cardinal angle with a slight auricular projection.

Age equivalence

P. dedaleus was described from the "Middle Limestone" which is considered to be early Givetian in age. McGill's comparable specimens were obtained from the middle Givetian beds of Carcajou Ridge, Northwest Territories.

Occurrence

Caribou Island.

Family BAIRDIIDAE Sars, 1888

Genus BAIRDIANELLA Harlton, 1929

Bairdianella sp. A

Plate IV, figures 1-3.

Description

Carapace elongate, bairdioid in lateral view; fusiform in dorsal view. Left valve overlaps right valve only along ventral border. Dorsal border is slightly convex, posterodorsal border straight and steeply inclined, anterodorsal border straight and less gently inclined. Posterior bluntly pointed at ventral surface; anterior sharply rounded at midline. Ventral margin concave. Greatest height anterior, greatest width central. Surface smooth.

Dimension of figured specimens

Length 0.54 mm., height 0.28 mm., width 0.23 mm.

Remarks

These specimens are placed in Bairdianella Harlton because of their low posterior ends.

Occurrence

Caribou Island.

Bairdianella ? sp. B

Plate IV, figures 4-6.

Description

Carapace bairdioid, elongate, subtriangular in lateral view; ovate in dorsal view. Left valve overlaps right valve on ventral margin. Dorsal

margin broadly convex. Posterior end extended into a short blunt spine at ventral surface. Anterior end broadly rounded, meets straight ventral border at distinct angle. Venter flat. Greatest height slightly anterior, greatest width posterior. Width greater than height. Surface smooth.

Dimensions of figured specimen

Length 0.61 mm., height 0.32 mm., width 0.33 mm.

Remarks

In comparison with B. sp. A, B. ? sp. B differs in its straight ventral border and greater convexity.

Occurrence

Caribou Island.

Genus BASCHKIRINA Rozhdestvenskaya, 1959

Baschkirina sp. cf. B. memorabis Rozhdestvenskaya

Plate IV, figures 7-9.

Synonymy

Baschkirina memorabis Rozhdestvenskaya, 1959, U.S.S.R. Acad. Sci., Bashkirian Div., pp. 99-100, pl. 27, figs. 1-3.

Description

Carapace elongate, inequivalved, and irregularly subtriangular in shape in lateral view. Left valve overlaps right valve on anterior and ventral margins. Dorsal margin straight and gently inclined; hinge line straight, lies in a depression. Posterodorsal margin straight, steeply inclined; posterior pointed at ventral margin and terminates in spine in right valve. Anterior margin broadly rounded. Ventral margin concave.

Greatest height anterior, greatest width at midline. Greatest convexity located near ventral in left valve, near dorsal in right valve. Surface smooth.

Dimensions of figured specimen

Length 0.75 mm., height 0.29 mm., width 0.30 mm.

Remarks

There appears to be only a slight difference in these specimens from Rozhdestvenskaya's material. The specimens from Caribou Island lack the ventral tongue where the left valve overlaps the right valve.

Age equivalence

B. memorabis was obtained from the Biya beds of Eifelian Age by Rozhdestvenskaya.

Occurrence

Caribou Island.

Baschkirina sp.

Plate IV, figures 10-12.

Description

Carapace irregularly deltoid shape in lateral view. Left valve overlaps right valve on ventral margin in form of two lobes. Dorsal border straight and inclined; hinge line straight and incised in posterior portion. Posterodorsal margin straight and steeply inclined, anterior border broadly rounded. Ventral border slightly convex in left valve, concave in right valve. Posterior bluntly pointed, slightly above ventral margin. In ventral view, right valve extends in posterior to form a blunt spine. Contact margin

of valves in anterior project as a keel. Greatest height slightly anterior, greatest width anterior with tapering toward the posterior. Greatest convexity located near ventral in left valve, near dorsal in right valve. Surface smooth.

Dimensions of figured specimen

Length 0.62 mm., height 0.32 mm., width 0.28 mm.

Remarks

This species is distinguished from Baschkirina sp. cf. B. memorabis by its slightly convex ventral margin of the left valve and the overlap of left valve over right valve on ventral surface in form of two irregular lobes.

Age equivalence

All described species of Baschkirina have been reported from beds of Eifelian Age from the U.S.S.R.

Occurrence

Caribou Island.

Genus RECTOBAIRDIA Sohn, 1960

Rectobairdi lacunosa (Rozhdestvenskaya) n. comb.

Plate IV, figures 13-15.

Synonymy

Bairdia lacunosa Rozhdestvenskaya, 1959, U.S.S.R. Acad. Sci., Baschkirian Div., pp. 72-74, Pl. 19, fig. 3.

Description

Carapace bairdioid, elongate with pointed posterior and anterior ends. Left valve overlaps right valve on dorsal and ventral margins; no

apparent overlap on ends. Dorsal margin straight in right valve, slightly convex in left valve. Anterodorsal margin straight and inclined, posterodorsal margin concave. Ventral margin concave. Posterior point lies at midline, anterior point dorsal to midline. Greatest height in front of midlength, greatest width at midlength. Surface of well-preserved specimen punctate.

Dimensions of figured specimen

Length 0.95 mm., height 0.46 mm., width 0.40 mm.

Remarks

These specimens are placed in Rectobairdia Sohn because of their straight to slightly convex dorsal margins.

Age equivalence

Rozhdestvenskaya reported R. lacunosa from the Biya beds which are Eifelian in age.

Occurrence

Caribou Island.

Family BEECHERELLIDAE Ulrich, 1894

Genus ACANTHOSCAPHA Ulrich and Bassler, 1923

Acanthoscapha sp. cf. A. navicula (Ulrich) Berdan

Plate V, figures 1-3.

Synonymy

Beecherella navicula Ulrich, 1891, Am. Geol., v. 8, p. 203, pl. 2, figs. 8-9.

Description

Carapace elongate with anterodorsal dorsal spine; spindle shaped in dorsal view. Left valve larger than right valve with overlap on postero-dorsal, anterodorsal, and ventral borders. Hinge line straight, depressed, and less than one-half total length of entire carapace. Dorsal margin gently convex. Ventral margin concave, curves to form anterodorsal and anteroventral margins. Anterior end produced as an upward directed spine, posterior end bluntly rounded and lower than anterior end. In ventral view, anteroventral and posteroventral contact margins project as keels. Greatest height anterior, greatest width slightly posterior. Surface smooth.

Dimensions of figured specimen

Length with spine 0.78 mm., length without spine 0.70 mm., height 0.28 mm., width 0.24 mm.

Remarks

Only one specimen was found which appears to be identical to A. navicula described by Ulrich.

Age equivalence

The original specimens described by Ulrich came from the lower Helderbergian beds of New York which are Early Devonian in age.

Occurrence

Caribou Island.

Acanthoscapha devonica (Kesling and Sohn) n. comb.

Plate V, figures 4-6.

Synonymy

Alanella devonica Kesling and Sohn, 1958, Jour. Paleont., v. 32, pp. 522-523, pl. 78, figs. 1-17, text-figs. 1-3.

Description

Carapace elongate, acuminate at each end. Left valve larger than right valve with overlap on anterodorsal, posterodorsal, and ventral margins. Hinge line straight, incised, less than one-half total length of carapace. Ventral border concave, curving smoothly to form anteroventral and posteroventral borders. Posteroventral margin more gently inclined than anteroventral margin.

In ventral view, left valve overlaps right valve in form of tongue. Posteroventral and anteroventral margins developed as keels with concave areas on either side. Concave area longer, narrower, and more distinct in posteroventral end. Greatest height anterior, greatest width slightly anterior. Surface smooth.

Dimensions of figured specimen

Length 0.86 mm., height 0.30 mm., width 0.25 mm.

Age equivalence

A. devonica was first found in the Centerville Member of the Ludlowville Shale in western New York by Kesling and Sohn. This unit is interpreted to be Eifelian in age.

Occurrence

Caribou Island.

Family RISHONIDAE Sohn, 1960

Genus RISHONA Sohn, 1960

Rishona epicypha (Kesling and Kilgore) Sohn

Plate V, figures 7-9.

Synonymy

Bairdia epicypha Kesling and Kilgore, 1955, Jour. Paleont., v. 29, p. 189, New name for B. gibbera Kesling and Kilgore, 1952.

Bairdia gibbera Kesling and Kilgore, 1952, Michigan Univ. Mus. Paleont. Contrib., v. 10, p. 14, pl. 4, figs. 9-17.

Description

Carapace subtriangular in lateral view with pronounced indentation in posterodorsal part of border. Right valve overlaps left on all borders except ventral border where the right valve overlaps the left valve. In dorsal view, right valve overlaps right valve in two broad lobes. Dorsal border slightly convex, anterior border broadly rounded. Posterior border nearly vertical for one-quarter of distance then slopes more gently to meet ventral border in form of a blunt point. Ventral surface straight. Greatest height and width at midline. Surface smooth.

Dimension of figured specimen

Length 0.69 mm., height 0.47 mm., width 0.42 mm.

Age equivalence

R. epicypha was reported by Kesling and Kilgore from the Genshaw Formation in Michigan which is interpreted to be Eifelian in age.

Occurrence

Caribou Island.

Family BAIRDIOCYPRIDIDAE Shaver, 1961

Genus PSEUDOBYTHOCYPRIS Shaver, 1958

?Pseudobythocypris praepilatus (Polenova) McGill

Plate V, figures 10-12.

Synonymy

Bairdiocypris praepilatus Polenova, 1960, Trudy V.N.I.G.R.I., No. 152, p. 64, pl. 8, figs. 5-6.

Pseudobythocypris praepilatus McGill, 1967, Internat. Dev. Sympos. Proceed., in press.

Remarks

Several steinkerns were collected whose general outline is similar with Polenova's material from the Kuznetz Basin, U.S.S.R. These steinkerns also closely resemble McGill's specimens from Carcajou Ridge, Northwest Territories.

Dimensions of figured specimen

Length 0.46 mm., height 0.36 mm., width 0.23 mm.

Age equivalence

Polenova has given the age of P. praepilatus as early Eifelian in the Kuznetz Basin, U.S.S.R. McGill's specimens are from the middle Givetian Kee Scarp Formation.

Occurrence

Caribou Island.

Family PACHYDOMELLIDAE Berdan and Sohn, 1961

Genus MICROCHEILINELLA Geis, 1933

Microcheilinella sp.

Plate V, figures 13-15.

Description

Elongate, ellipsoidal carapace. Valves asymmetric with left valve larger than right valve; overlap entire along free margin. Dorsal margin slightly convex; hinge line straight, depressed, and less than total length. Both anterior and posterior ends rounded; posterior end lower than anterior end. Ventral border straight.

In dorsal view, hinge line dextral to midwidth. In posterior view, left valve asymmetrically larger than right valve; free edge slants from dextral side of dorsum to midwidth of venter. Greatest height anterior to midlength, greatest width posterior with tapering toward anterior. Surface smooth.

Dimensions of figured specimen

Length 0.52 mm., height 0.26 mm., width 0.32 mm.

Remarks

This species is differentiated from other species described from the Middle Devonian by its dextral position of hinge line in relation to midwidth and the slanted character of free edge in posterior view. In most species, the free edge is either vertical or inclined from the sinistral side of dorsum to midwidth or dextral side of the venter.

Occurrence

Caribou Island.

Family CYPROSINIDAE Whidborne, 1890

Genus A. nov.

Plate V, figures 16-18.

Description

Carapace elongate, ellipsoidal with left valve asymmetrically larger than right valve. Siphon extends along entire ventral surface and produced as upward directed caudal process in posteroventral portion. Dorsal border slightly convex; hinge line nearly straight, incised, and dextral to midwidth. Anterior end broadly rounded; venter flat. In posterior view, free edge inclined from dextral part of dorsal, to midwidth of venter. Greatest height central, greatest width posterior, greatest convexity ventral. Surface smooth..

Dimensions of figured specimen

Length 0.76 mm., height 0.34 mm., width 0.42 mm.

Remarks

Specimens of this new genus from Caribou Island are referred to Family Cyprosinidae Whidborne because of the presence of an upward directed posteroventral caudal process with siphon.

Age equivalence

The only genus reported from this family is from the Devonian of England.

Occurrence

Caribou Island.

CHAPTER FOUR

DEPOSITIONAL AND TECTONIC HISTORY

Prior to the incursion of the Paleozoic seas, the surface of the Precambrian Shield was not completely peneplaned. Relict topography of mountain ranges and features produced by late Precambrian or early Paleozoic orogenies significantly affected the nature of the Lower Paleozoic sediments and their distribution.

The facies and distribution of the Cambrian strata suggest that the Tathlina High, Peace River Arch, Chipewyan Lakes Sill, and the Western Alberta Ridge existed as low relief features prior to the initial invasion of the Paleozoic seas in the Cambrian (Van Hees, 1964, pp. 26-28) (see fig. 7). These features were later rejuvenated to form prominent land masses. The deposition of the Cambrian and Early Ordovician sediments was restricted to the plains region south of the Peace River Arch and Chipewyan Lakes Sill and the Cordilleran belt to the west.

Following the major late Early to early Middle Ordovician emergence and erosion, widespread subsidence and transgression commenced. Marine deposition was resumed in transgressions in the Cordilleran belt as in the preceding Cambrian and Early Ordovician seaway. In the interior, deposition took place in the Williston and Mackenzie Basins which had become clearly defined by subsidence. The invasion of the Williston Basin came from the southwest through the Cordilleran trough of Idaho and Wyoming. The Peace River Arch and Tathlina High probably remained positive and formed a barrier between the thin northern extension of the Williston Basin formations and the Ordovician - Silurian deposits of the Mackenzie Basin.

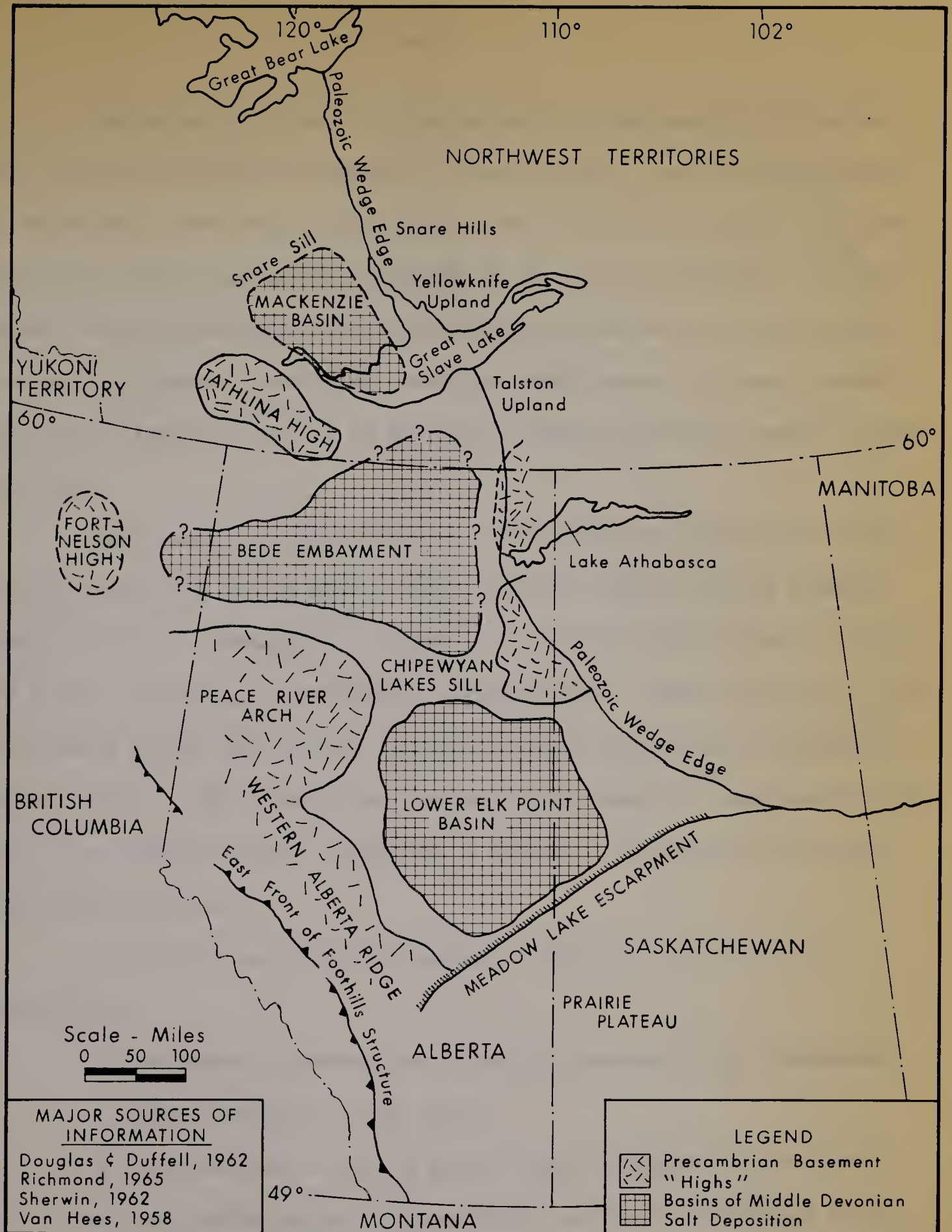


FIGURE 7 OUTLINE MAP OF WESTERN CANADA SHOWING PRE CHINCHAGA-CONTACT RAPIDS TECTONIC FRAMEWORK

In the northern part of the map area in the eastern Mackenzie Basin, the Old Fort Island Formation, a mature basal quartzose sandstone, was deposited in the topographic lows of the Precambrian surface. As the Precambrian Shield was slowly inundated by the Middle Ordovician sea, the detrital material was repeatedly reworked and deposited as a thin veneer of clean, well-sorted, quartzose sandstone which formed the basal deposit. The Old Fort Island Formation is homotaxial with the Winnipeg and St. Peter Formations.

This sandstone deposition was followed by the inflowing of fine-grained clastics of the La Martre Falls Formation which carries a Middle Ordovician fauna. In outcrop, the beds of La Martre Falls Formation often show primary slumping, brecciation, ripple-markings, scour structures, and salt crystal moulds which point to shallow water and subaerial deposition (Norris, 1965, p. 18). This fine-grained clastic unit is conformably overlain by the Chedabucto Lake Formation, a massive dolomite containing an Upper Ordovician fauna.

The Ordovician seas were partly restricted to the south as attested by:

1. The marked thinning and evaporitic nature of the Chedabucto Lake Formation in the south.
2. The thinning of the La Martre Falls Formation to the south.
3. The shallow water and evaporitic nature of the Mirage Point Formation which probably occupies the same stratigraphic position as the latter formations to the north.

The Mirage Point Formation is also very thin both in outcrop and subsurface indicating either pre-Middle Devonian erosion or the existence of an upland.

The Ordovician seas probably lapped over the broadly arched peneplane surface of the Yellowknife Upland (Douglas and Norris, 1959, p. 4) (see fig. 7) which extended west of the North Arm of Great Slave Lake. In the Snare region, an extensive range of low monadnocks which trend N.45°E. with a relief of 1,000 feet rise above the peneplane (Douglas and Duffell, 1962, fig. 4). These monadnocks are postulated to have extended to the southeast and acted as a restricting mechanism to deposition both in Ordovician and early Middle Devonian times. These monadnocks are herein referred to as the Snare Sill (see fig. 7). East of Lac La Martre, many monadnocks of resistant Precambrian rock protrude through all the Ordovician strata and in one case through the Middle Devonian Chinchaga Formation (Douglas and Norris, 1959, p. 4).

To the south, the Ordovician strata are limited by the Tathlina High. To the southeast, the rocks are limited by the MacDonald and associated fault scarps which bound the Talston Upland to the south (Douglas and Duffell, 1962, p. 156) (see fig. 7).

In Late Ordovician or Early Silurian time, the Great Slave Lake region was uplifted. The area was probably not inundated again until the seas invaded the area in early Middle Devonian time, since there is no evidence to suggest that Silurian rocks were deposited in the region. The western Mackenzie Basin and the Williston Basin continued to subside and sedimentation probably continued into the Silurian without any hiatus. The Late Ordovician-Early Silurian emergence in the Great Slave Lake region is reflected in the Williston Basin by thin sheets of argillaceous material containing lenses of coarse, frosted sand grains (Porter and Fuller, 1964, p. 38).

White (1959, pp. 66-70) recognized a period of major Cordilleran

orogeny occurring sometime during the post-Ordovician and the pre-Mississippian interval which he termed the Cariboo Orogeny. The supporting evidence is based on the relationship between highly metamorphosed probable Upper Proterozoic to Lower Paleozoic rocks which are predominantly metasedimentary and the overlying Carboniferous and Permian beds.

There were probably two periods of emergence in the Great Slave Lake area during Early Paleozoic time. At the end of Ordovician time, the land mass was slightly uplifted and the upwarps around the basins were rejuvenated. This movement was probably related to the Taconic Orogeny of North America. Evidence for the existence of a stratigraphic break at this level has been documented by Jackson et al., (1965). During the post-Silurian to late Early Devonian interlude, the craton was emergent and severe erosion took place. This widespread emergence was probably accompanied by orogeny in the Western Cordillera (see Baadsgaard, Folinsbee, and Lipson, 1961; Rapson, 1963; and Leech, 1960). For this reason, Webb (1964, p. 221) restricted the term Cariboo Orogeny of White (1959, p. 66) to this post-Silurian to late Early Devonian activity.

In the Great Slave Lake region, the Cariboo Orogeny (sensu Webb, 1964) was reflected in the differentiation of the tectonic elements. A south-trending range of Precambrian highs which included the Tathlina High, Fort Nelson High, Peace River Arch, and the Western Alberta Ridge extended from the southern part of the Northwest Territories into southern Alberta (see fig. 7). These features had previously existed as low relief features, but did not become salient land masses until Devonian time. Following the emergence, the entire region was modified by erosion. The Precambrian highs were resistant to erosion and remained as prominent land masses. The flanking low-land areas were further lowered in elevation.

The low lying area east of the south-trending Precambrian highs became the Elk Point Basin, the area to the west, the Cordilleran Basin, and the area north of the Tathlina High formed the Mackenzie Basin. The Elk Point Basin had two westward extensions, the Lower Elk Point Basin to the south and the Bede Embayment to the north which were separated by the Peace River Arch.

The southern limit of the Lower Elk Point Basin was formed by the Meadow Lake Escarpment along the eroded edge of the Prairie Plateau (Van Hees, 1958, fig. 1). The Prairie Plateau was formed by a thick sequence of resistant Upper Ordovician Red River dolomite which dipped gently to the south. Silurian, Ordovician, and Cambrian sediments were removed north of the escarpment during the pre-Middle Devonian erosional interlude. Van Hees (1958, p. 73) suggested that the erosion of the escarpment with its arcuate trend was controlled by a Precambrian fault system.

Early Middle Devonian sedimentation is characterized by evaporite deposition in the Great Slave Lake region. The fundamental depositional environment of marine evaporites has been illustrated by Borchert and Muir (1964, p. 73) (see fig. 8). In this figure, three forebasins intervene between the marginal sea and the open ocean. The forebasins are separated by sills or bar zones and joined by narrow, shallow channels.

Before the various salts will precipitate, the concentration of the sea water must be increased until the solubility of the salt is exceeded. To develop and maintain this concentration, evaporation must exceed precipitation plus run off and restrictions to free circulation must exist. In a basin, surface currents flow in the direction of increasing salinity and bottom currents flow toward water of low salinity (Scruton, 1953, p. 2501).

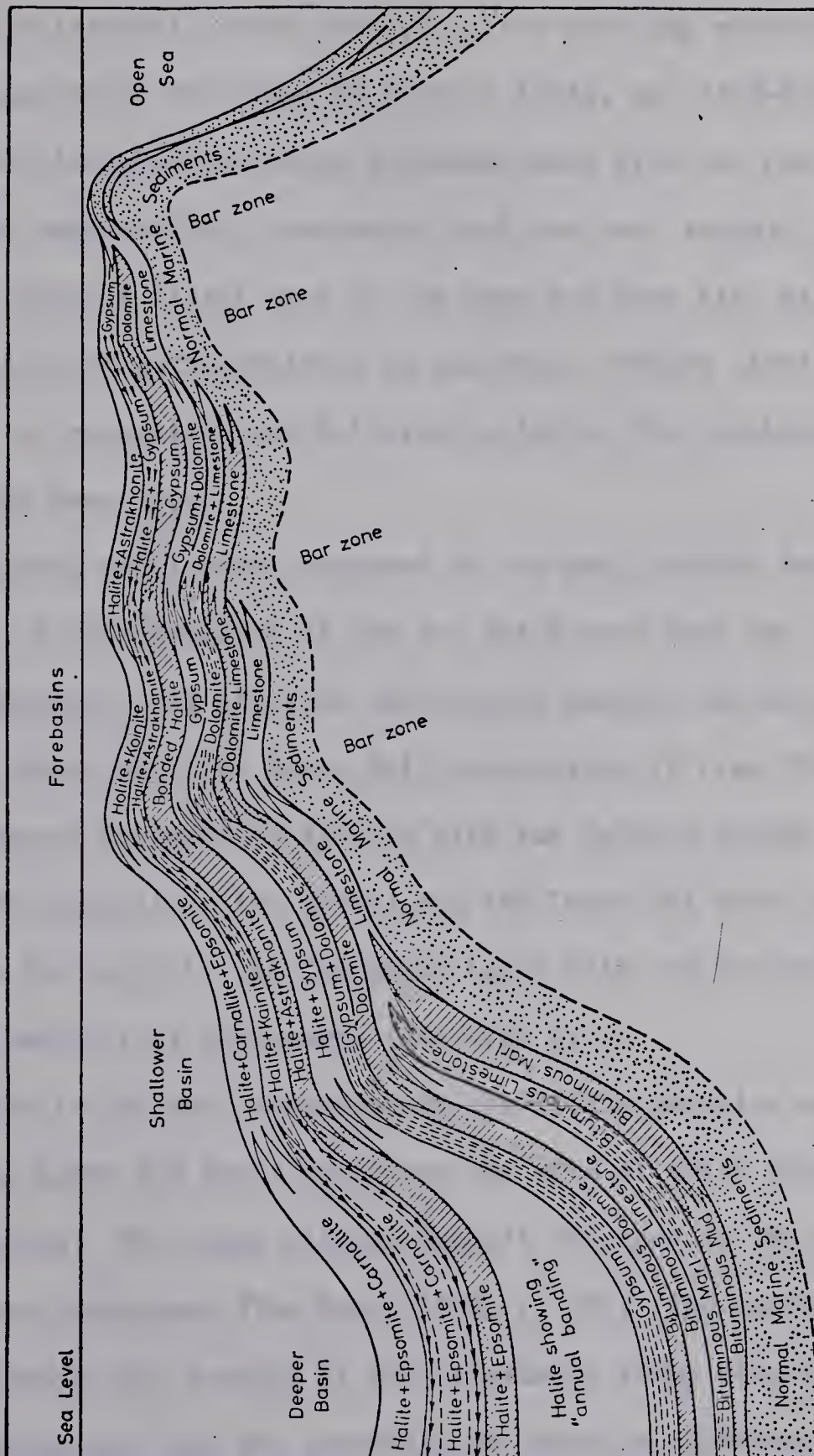


Figure 8. Cross-section of evaporite basin showing successive stages in primary facies variation as the basin becomes progressively more isolated from the open sea. (from Bochart and Muir, 1964, p. 89).

Thus during evaporation, water is replenished by inflow in response to a hydrostatic head. Outflow of dense brine may be restricted by a physical barrier or by frictional forces resulting from opposing current flow, the latter mechanism being explained by Scruton (1953, pp. 2503-2504). A strong horizontal salinity gradient which increases away from the open sea results in the lateral segregation of sediments with the most soluble salts being deposited in the most distal area to the open sea (see fig. 8). In figure 8, isochronic units are differentiated by patterns. Facies lines are drawn between salts to emphasize that different salts in the isochronic units did form at the same time.

Regional subsidence commenced in the early Middle Devonian accompanied by a transgression of the sea which came from the northwest. Evaporite deposition took place in three major basins: the most northern, the Mackenzie Basin with the Snare Sill restricting it from the open sea; the Bede Embayment in northern Alberta with the Talston Upland acting as sill and restricting it to the north; and the Lower Elk Point Basin restricted to the north by the Chipewyan Lakes Sill and bounded to the south by the Meadow Lake Escarpment (see fig. 7).

Prior to the main incursion of the Middle Devonian sea from the northwest, the Lower Elk Point Basin was the site of thick clastic and halite deposition. The basal clastic deposit thickens in the proximity of the Meadow Lake Escarpment (Van Hees, 1958, p. 72). The sediments were probably derived by the erosion of the relatively steep slopes of the Meadow Lake Escarpment and the reworking of Cambrian clastics. The clastic unit is overlain by a thick halite deposit, the Lotsberg Formation. Kesling and Takagi (1961, pp. 35 and 37) and Van Hees (1958, p. 73) postulated the existence of two channels that admitted normal marine water into the Lower

Elk Point Basin during Lower Elk Point time. One of the channels entered from the Precambrian Shield to the east and the other one along the base of the Meadow Lake Escarpment.

The basal deposit of the early Middle Devonian sea which came from the northwest in the Mackenzie Basin was a thin carbonate unit, the Fitzgerald Formation, conformably overlies a detrital unit, the La Loche Formation. The invasion of the Middle Devonian sea in the Bede Embayment probably represented the first inundation of the area. The La Loche Formation is the basal reworked detrital unit of granitic derivation and composition which was deposited by the transgressing sea in the topographically low areas in the Precambrian Shield. The Ernestina Lake Formation, the equivalent of the Fitzgerald Formation in the Lower Elk Point Basin, overlies the Lotsberg salt.

The initial restriction of the seas during the early Middle Devonian is reflected in the development of bituminous dolomites assigned to the Fitzgerald Formation in the deeper parts of the Bede Embayment (see plate 1, fig. 1). With the restriction, the circulation at depth in the basin was reduced resulting in the reduction in the supply of oxygen (Borchert and Muir, 1964, p. 88). When the organisms living in the well-aerated surface waters died, their remains sank to the bottom. Due to lack of oxygen, the organisms did not completely decompose and gave rise to bituminous material. The bituminous dolomites pass laterally into well-aerated, shallow water dolomites which carry the coral Planetophyllum planetum and an associated fauna (see plate 1, figs. 2 and 3).

As the brines became more concentrated, gypsum was precipitated in the deeper parts of the basin which grades laterally into dolomite. This concentration of brines is supported by the occurrence of a restricted fauna of only one species, the ostracode Welleria meadowlakensis, in the

upper part of the Fitzgerald dolomite.

Succeeding halite with minor detrital material, anhydrite, and carbonates was deposited in the three basins. Since halite precipitation is sensitive to slight movements of the sill, slight downwarping results in influx from the open sea, dilution of brines, and reversion to the precipitation of the more soluble deposits (Borchert and Muir, 1964, p. 76). Rainy seasons may have resulted in the inflow of detrital material into the basin.

The Cold Lake Formation in the Bede Embayment and its equivalent in the Mackenzie Basin, the upper part of the Lower Elk Point Evaporites, are composed almost entirely of clear coarsely crystalline halite with dispersed red mud (see plate 1, figs. 4 and 5). The halite is characterized by its very small amount of bromide (< 0.0046 wt. %) and sulphate (see table 6).

The first halite to precipitate from normal present-day sea water would have 0.0075 wt. % bromide (Wardlaw and Watson, 1966, p. 264). Bromide in halite increases gradually with further crystallization, because the parent solution becomes enriched in bromide relative to chloride. Solution and subsequent crystallization will lead to the reduction of bromide in the halite (Wardlaw and Watson, 1966, p. 264). It is not possible to obtain halite with a bromide content of much less than 0.00069 wt. % from a brine formed by the solution of halite in sea water. Assuming that the composition of the sea water was the same in the Devonian as it is at present, the halite contains so little bromide that it could not have crystallized from sea water. It is probable that the halite was the result of the solution of halite in sea water with subsequent crystallization. The small amount of sulphate and the lack of cycles also indicates that the halite is secondary (personal

TABLE 6

WEIGHT PERCENTAGES OF BROMIDE AND SULPHATE IN SOME LOWER ELK POINT SALTS

<u>Location</u>	<u>Wt. % Br.</u>	<u>Wt. % SO₄</u>
Imperial Crossroads 15-32 15-32-109-19W5 Cold Lake Salt 4,708-4,821 feet S-1 (4,713-4,716 feet)	0.0017	0.025
Imperial Surrence Lake 15-24 15-24-109-17W5 Cold Lake Salt, 4,272-4,396 feet S-2 (4,315-4,318 feet) S-3 (4,319-4,322 feet) S-4 (4,323-4,325 feet)	0.0026 0.00063 0.0038	0.030 0.050 0.20
Imperial Triad Davidson Creek P-2 62°11'45"N. 118°15'05"W. Lower Elk Point Salt 2,156-2,372 feet S-5 (2,156-2,158 feet) S-6 (2,159-2,162 feet) S-7 (2,168-2,169 feet)	0.0037 0.0046 0.0022	3.98 1.28 3.80

communication with A. M. Klingspor, Imperial Oil Enterprises Ltd.),

Two possibilities exist for the time and method of solution of the halite. Firstly, contemporaneous solution at the time of halite deposition caused by renewed influxes of less concentrated brines may have occurred. Also in the Bede Embayment, a period of emergence or shallow water conditions existed at the end of salt deposition while the Lower Member of the Chinchaga Formation was being deposited in the Mackenzie Basin. The Cold Lake salt in the Bede Embayment might have been dissolved at this time.

A second possibility is that the solution was brought about by the solutions released during the metamorphism of gypsum to anhydrite. This mechanism has been discussed by Borchert and Muir (1964, pp. 129-135). The halite is overlain and underlain by thick deposits of anhydrite. Conley and Bundy (1959, p. 70), Borchert and Muir (1964, p. 134), and others have concluded that the precipitation of anhydrite is improbable, and that most present deposits of the mineral were precipitated as gypsum. With burial and increasing temperatures, the gypsum will convert to anhydrite which results in reduction of volume and liberation of CaSO_4 - saturated solutions which are capable of dissolving halite (Borchert and Muir, 1964, p. 132).

This conversion process has undoubtedly taken place in the Chinchaga anhydrites which overlie the halite. The anhydrite in many places is severely deformed suggesting mobility and flowage during the conversion. On the south shore of Great Slave Lake, the salt interval is represented by a red mudstone breccia (see plate 1, fig. 4) which is overlain by severely deformed anhydrite with incorporated fragments of green mudstone (see plate 1, figs. 8-10). Halite was probably deposited here but was later dissolved with the concentrated brines flowing into the deeper part of the basin.

A similar evaporite succession is developed in each basin except for the basal salt, the Lotsberg Formation, in the Lower Elk Point Basin to the south. If the open sea connection was to the northwest of the Mackenzie Basin, a north to south salinity gradient should have been developed with the segregation of the more soluble salts to the south. Since this is not the case, the Lower Elk Point Basin and possibly the Bede Embayment may have had connections to the open sea. Kesling and Takagi (1961, pp. 35 and 37) and Van Hees (1958, p. 73) postulated the existence of channels that admitted marine water into the Lower Elk Point Basin from the south and east during early Middle Devonian time. This postulation was based on the facies distribution of the Lower Elk Point sediments and the size and distribution of specimens of Welleria meadowlakensis in the Ernestina Lake Formation. In the Bede Embayment, a narrow seaway may have connected it with the Cordilleran Basin to the west.

These Lower Elk Point evaporite strata are laterally equivalent to carbonates north and west of the Snare Sill which acted as a restricting mechanism to the open sea to the northwest (Bassett, 1961, pp. 483-486; Douglas et al., 1963, fig. 23).

The overlying Chinchaga Formation is divided into two informally designated members by a detrital unit (see plate 1, fig. 7). The Lower Member, which is restricted to the Mackenzie Basin, consists primarily of anhydrite and represents a continuation of the evaporite deposition from below. Emergent or shallow water conditions probably existed to the south while the Lower Member was being deposited to the north.

During the deposition of the Upper Member of the Chinchaga Formation, the sea transgressed over a wider area. The Prairie Plateau was

probably emergent during most of early Middle Devonian time. The Ashern Formation, a thin reworked regolithic soil unit which is restricted to the Prairie Plateau, is probably equivalent to the upper part of the Chinchaga Formation. The unit represents the widespread transgression of the Lower Elk Point sea over the Meadow Lake Escarpment onto the Prairie Plateau. In the area of the Chipewyan Lakes Sill, anhydrite of the Chinchaga Formation grades laterally to the south into dolomites and shales of the Contact Rapids Formation. In the eastern Mackenzie Basin, a lateral gradation from anhydrite and dolomite to dolomite and limestone occurs in the Upper Member. This lateral segregation indicates that a salinity gradient was operative during deposition of the Chinchaga Formation. The distribution of Upper Chinchaga lithologies suggests the continuation of evaporitic conditions in the Bede Embayment which was surrounded to the north, west, and south by a sea of normal salinity.

Late Middle Devonian sedimentation commenced with the depositional conditions changing from evaporitic to normal marine. Carbonates were deposited over a wide area including the Lonely Bay, Pine Point, and Keg River Formations in the Great Slave Lake region.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

Two sequences are recognized in the succession of the Chinchaga and older Paleozoic formations in the Great Slave Lake area. A sequence, as defined by Sloss et al., (1949, p. 93), is an unconformity - bounded unit of strata of greater than group or supergroup rank. The sequence and the following hiatus represent a major tectonic cycle which includes subsidence, transgression, regression, emergence, and erosion. The inter-regional extent of the unconformities bounding these units indicates that the emergence which terminated each sequence was epeirogenic in nature.

The oldest sequence recognized in the Great Slave Lake area is the Tippecanoe Sequence which was defined by Sloss et al., (1949, p. 115) as those strata which overlie the Sauk Sequence, underlie the Kaskaskia Sequence, and range in age from Middle Ordovician (Chazyan) to Early Devonian. The older Sauk Sequence is present to the west in the Cordilleran belt and to the south in the plains region of western Canada. Rocks belonging to the Tippecanoe Sequence in the Great Slave Lake area are restricted to the Mackenzie Basin. The strata are limited to the south by the Tathlina High and to the southeast by the Talston Upland, a Precambrian high which was bounded by a southwest continuation of fault scarps of the East Arm of Great Slave Lake. This upland was active as a sill during early Middle Devonian sedimentation.

Subsidence and the advent of the early Middle Ordovician seas resulted in the deposition of a widespread basal quartzose sandstone which is termed the Old Fort Island Formation in the Great Slave Lake region. This unit is homotaxial with the St. Peter and Winnipeg Formations of the

mid-continent area. The sandstone is gradationally overlain by a red bed unit, the La Martre Falls Formation, which contains a Middle Ordovician fauna in the upper part in outcrop. A distinctive dolomite unit, the Mazenod Member, is developed locally within the lower part of the La Martre Falls Formation. A massive dolomite unit containing an Upper Ordovician fauna, the Chedabucto Lake Formation, conformably overlies the La Martre Falls Formation.

The latter two formations thin to the south with the Chedabucto Lake Formation becoming evaporitic in character. Both formations appear to grade laterally into the thin red bed unit, the Mirage Point Formation, which is developed south of the Snare Sill. The Snare Sill was the north-east - southwest trending chain of monadnocks which rose above the peneplaned surface of the Precambrian and affected sedimentation in the Great Slave Lake Area in Ordovician and early Middle Devonian time.

These strata of Ordovician age are unconformably overlain by Middle Devonian rocks. Since there is no evidence to suggest that Silurian strata were deposited in the area, it is suggested that emergent conditions existed in the Great Slave Lake area from Late Ordovician to early Middle Devonian time. The emergence in Late Ordovician time is supported by the inflowing of clastics into the Williston Basin where deposition continued uninterrupted into the Silurian.

The emergence in the Great Slave Lake area in Late Ordovician time was probably related to the Taconic Orogeny which was prominent in eastern North America. Thus the Ordovician rocks in the Great Slave region belong to Wheeler's (1963) Creek Sequence and the lower part of the

Tippecanoe Sequence as defined by Sloss et al., (1949).

Recent field evidence and age dating indicate a post-Silurian to late Early Devonian orogeny in the Western Cordillera which was accompanied by continent-wide emergence and erosion. This emergence which was accompanied by uplift, deformation, and plutonism in the Western Cordillera is termed the Cariboo Orogeny.

The Cariboo Orogeny resulted in the differentiation of the tectonic elements in the Great Slave Lake region with the development of three intracratonic basins: the Mackenzie Basin, the Bede Embayment, and the Lower Elk Point Basin. These were the site of evaporite deposition in early Middle Devonian time.

The strata deposited in the next depositional cycle in the Great Slave Lake ^{area} belong to the Kaskaskia Sequence. The Kaskaskia Sequence was defined by Sloss et al., (1949, p. 115; revised by Sloss, 1963, p. 100) as the strata which overlie the Tippecanoe and older rocks, underlie the Absaroka Sequence, and range in age from late Early Devonian to Mississippian (post-Chesteran).

Deposition of the Lower Elk Point sediments, which comprise the basal beds of the Kaskaskia Sequence in the Great Slave Lake area commenced with subsidence of the land mass and the flooding from the northwest of the three intracratonic basins which became clearly defined during the Cariboo Orogeny. Prior to this major incursion from the northwest, the Lower Elk Point Basin was the site of thick clastic and salt deposition. The source of the sea water needed for the salt deposition

probably entered through two channels to the south and east of the basin. These channels were probably in existence during most of early Middle Devonian time because of the lack of lateral segregation of the more soluble salts to the south in the overlying evaporite section.

The basal deposit of the early Middle Devonian sea which advanced from the northwest was a thin carbonate unit, the Fitzgerald Formation, which directly overlies Ordovician rocks south and immediately west of Great Slave Lake. The unit has yet to be recognized in the subsurface to the west of Great Slave Lake. In the Bede Embayment, the Fitzgerald Formation conformably overlies a thin detrital unit of granitic derivation and composition, the La Loche Formation.

The Fitzgerald Formation is characterized by a unique fauna consisting of the coral Planetophyllum planetum and the ostracode Welleria meadowlakensis which are restricted to this unit. The coral Planetophyllum planetum is associated with a megafauna and ostracode fauna in the lower part of the formation. Comparison of the ostracode fauna from the Fitzgerald Formation with other Devonian faunas of the U.S.S.R., eastern United States, and western Canada points to an Eifelian Age for the Fitzgerald Formation. A restriction in the basins resulted in supersaline conditions and the killing-off of the organisms except for the ostracode Welleria meadowlakensis which is limited to the upper part of the Fitzgerald Formation. This unit, on the basis of the above fauna, can be traced from west-central Saskatchewan to the North Arm of Great Slave Lake.

Further restriction in the three intracratonic basins lead to the deposition of thick evaporite succession composed predominantly of halite. This unit is termed the Cold Lake Formation in the Bede Embayment and Lower Elk Point Basin with its equivalent, the upper part of the Lower Elk Point Evaporites in the Mackenzie Basin. The lack of bromide, sulphate, and cycles in the halite indicates that the halite resulted from solution of halite in sea water with subsequent crystallization. It is postulated that this solution took place either contemporaneous to deposition of halite by less concentrated brines or after burial by SO_4 - concentrated solutions released during the metamorphism of gypsum to anhydrite which underlie and overlie the halite.

This evaporite section is laterally equivalent to carbonates which are developed northwest of the Snare Sill which acted as a restricting barrier to the open sea.

The overlying evaporites of the Chinchaga Formation are divided by a detrital unit into two informally designated members, the lower member being restricted to the Mackenzie Basin. The distribution of the lithologies of the Upper Member suggest the continuation of evaporite deposition in the Bede Embayment which was surrounded by a sea of normal salinity to the northwest and south.

In late Middle Devonian time, normal marine conditions prevailed over the Great Slave Lake area with widespread carbonate deposition.

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- Workman, L. E., 1953: Elk Point Formation in the Peace River region: Bull. Can. Petrol. Geol., v. 1, pp. 7-8.

PLATE I

Hand Specimen Photographs

(Except where noted, all magnifications are approximately X0.8)

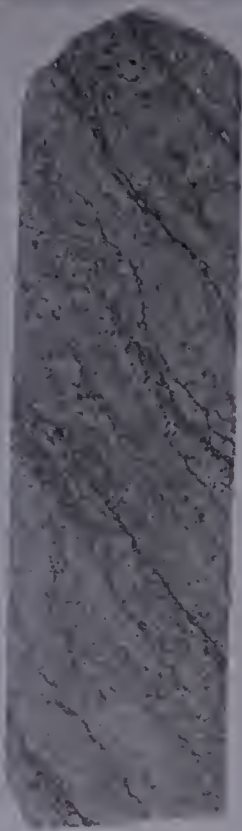
- Figure 1. Fitzgerald Formation: bituminous dolomite X1. (Imperial Jack Lakes No. 8-17 well, at 2,610 feet).
- Figure 2. Fitzgerald Formation: dolomite with Planetophyllum planetum. (Calstan Mikkwa River No. 12-23 well, at 3,812 feet).
- Figure 3. Fitzgerald Formation: dolomite with porous zones and bituminous partings. (Pyramid 202A drill hole, at 980 feet).
- Figure 4. Cold Lake equivalent: red dolomitic mudstone breccia. (Pyramid 202A drill hole, at 955 feet).
- Figure 5. Lower Elk Point Evaporites: clear, coarsely crystalline halite X1. (Imperial Triad Davidson Creek P-2 well, at 2,170 feet).
- Figure 6. Cold Lake Formation: clear, coarsely crystalline halite with dispersed red mud. (Imperial Surette Lake No. 15-24 well, 15-24-109-17W5th mer., at 1,316 feet).
- Figure 7. Chinchaga Formation (Detrital Unit): green mudstone breccia. (Imperial Cartridge B-72 well, at 1,083 feet).
- Figure 8. Chinchaga Formation: anhydrite with flowage structure. (Pyramid 202A drill hole, at 599 feet).
- Figure 9. Chinchaga Formation: anhydrite with flowage structure and argillaceous bands. (Pyramid 202A drill hole, at 857 feet).
- Figure 10. Chinchaga Formation: anhydrite, brecciated with mudstone at top. (Cominco G-4 drill hole, at 969 feet).



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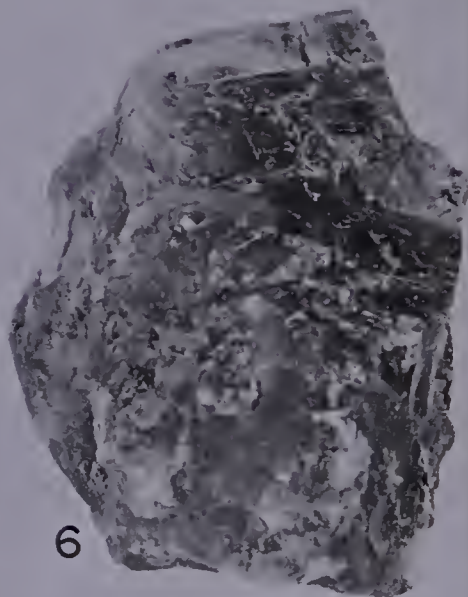
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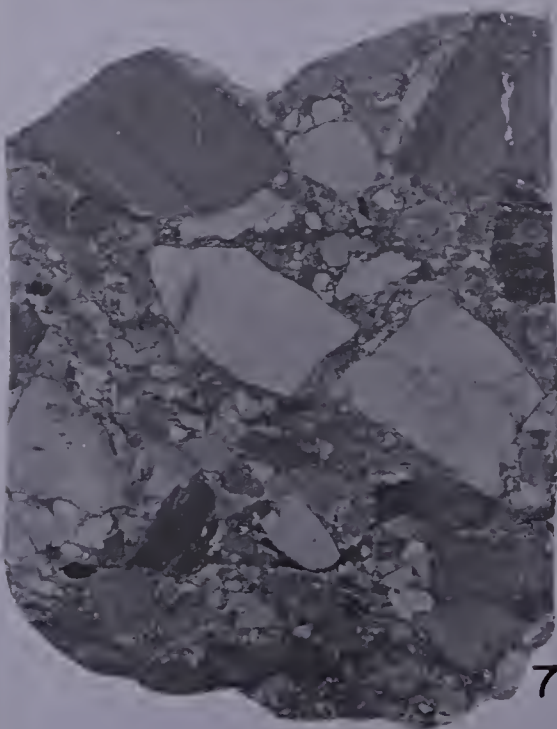
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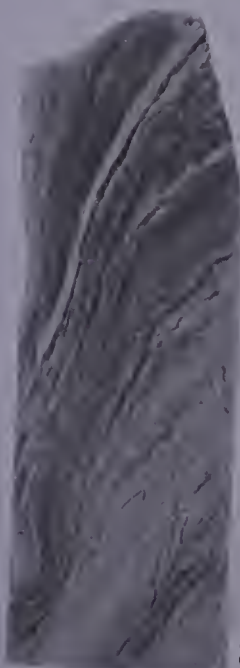
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PLATE I.

PLATE II

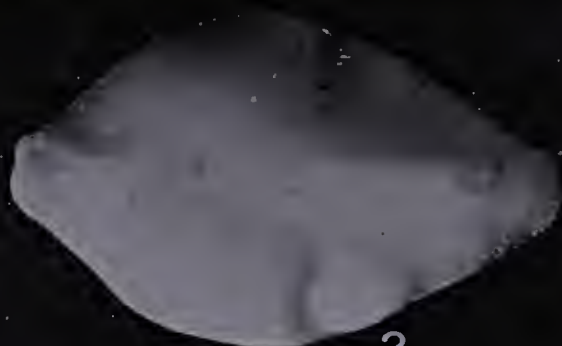
Welleria meadowlakensis and Planetophyllum planetum

Figures 1-6 Welleria meadowlakensis Kesling and Takagi: 1, 2, 3-
right lateral, dorsal, and ventral views of adult male
X42; 4, 5, 6- right lateral, dorsal, and ventral views
of adult female X42. (On Slave River between Fort
Fitzgerald and Fort Smith).

Figures 7-8 Planetophyllum planetum Crickmay: 7, 8- transverse
and longitudinal sections X5. (Calstan Mikkwa River
No. 12-23 well, at 3,812 feet).



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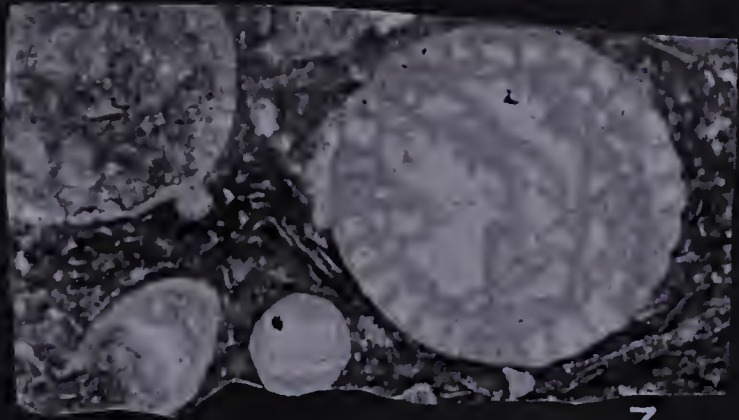
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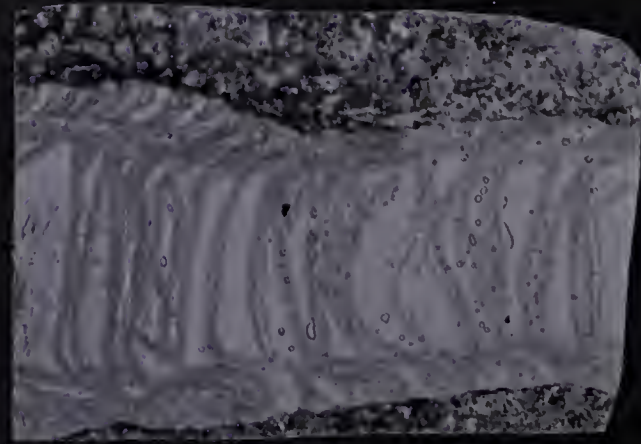
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PLATE II.

PLATE III

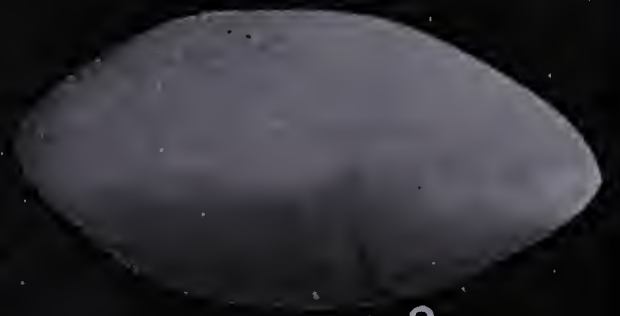
Ostracodes from the Fitzgerald Formation

(Except where noted, all magnifications are approximately X55).

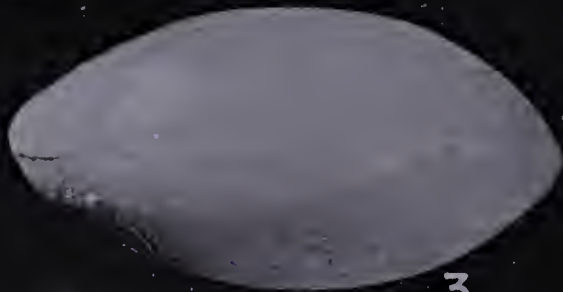
- Figures 1-3 Rozhdestvenskayites auriculiferous (Rozhdestvenskaya)
McGill: 1, 2, 3- right lateral, dorsal, and ventral
views X35. (Caribou Island).
- Figures 4-6 Eukloedenella ? sp.: 4,516 - left lateral, dorsal, and
ventral views (Caribou Island).
- Figures 7-10 Eylanella joussardensis McGill: 7, 8, 9, 10- right
lateral, left lateral, dorsal, and ventral views.
(Caribou Island).
- Figures 11-13 Paraparchites sp. cf. P. dedaleus (Rozhdestvenskaya)
McGill: 11, 12, 13- right lateral, dorsal, and ventral
views. (Caribou Island).



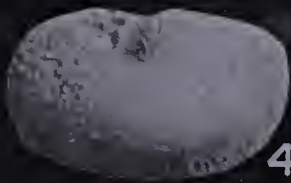
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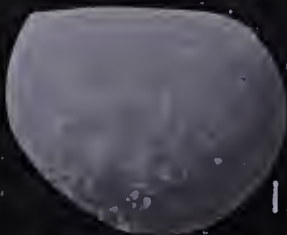
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PLATE III.

PLATE IV

Ostracodes from the Fitzgerald Formation

(All magnifications are approximately X55)

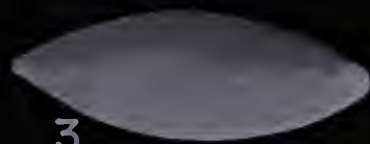
- Figures 1-3 Bairdianella sp. A: 1, 2, 3- right lateral, dorsal,
and ventral views. (Caribou Island).
- Figures 4-6 Bairdianella ? sp. B: 4, 5, 6- right lateral, dorsal,
and ventral views. (Caribou Island).
- Figures 7-9 Baschkirina sp. cf. B. memorabis Rozhdestvenskaya:
7, 8, 9- right lateral, dorsal, and ventral views.
(Caribou Island).
- Figures 10-12 Baschkirina sp.: 10, 11, 12- right lateral, dorsal,
and ventral views. (Caribou Island).
- Figures 13-15 Rectobairdia lacunosa Rozhdestvenskaya: 13, 14, 15-
right lateral, dorsal, and ventral views. (Caribou
Island).



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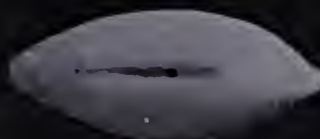
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PLATE IV.

PLATE V

Ostracodes from the Fitzgerald Formation

(All magnifications are approximately X55)

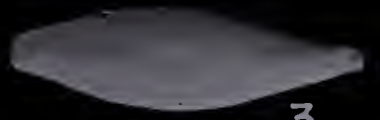
- Figures 1-3 Acanthoscapha sp. cf. A. navicula (Ulrich) Berdan:
1, 2, 3- right lateral, dorsal, and ventral views.
(Caribou Island).
- Figures 4-6 Acanthoscapha devonica (Kesling and Sohn) n. comb.:
4, 5, 6- left lateral, dorsal, and ventral views.
(Caribou Island).
- Figures 7-9 Rishona epicyphae (Kesling and Kilgore) Sohn:
7, 8, 9- right lateral, dorsal, and ventral views.
(Caribou Island).
- Figures 10-12 ?Pseudopythocyris praepilatus (Polenova) McGill:
10, 11, 12- left lateral, dorsal, and ventral views.
(Caribou Island).
- Figures 13-15 Microcheilinella sp.: 13, 14, 15- right lateral,
dorsal, and ventral views. (Caribou Island).
- Figures 16-18 Genus A nov.: 16, 17, 18- right lateral, dorsal,
and ventral views. (Caribou Island).



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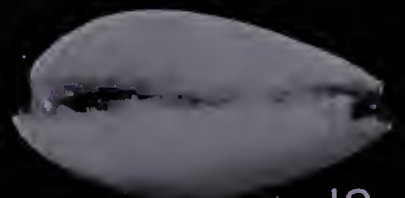
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PLATE V.

APPENDIX

Well Logs

Grain and crystal size classes are presented in the following table:

<u>Grain Size</u>	<u>Size in mm.</u>	<u>Crystal Size</u>
Very coarse	1	Very coarse
-----		-----
Coarse	1/2	Coarse
-----		-----
Medium	1/4	Medium
-----		-----
Fine	1/8	Fine
-----		-----
Very fine	1/16	Very fine
-----		-----
Micrograined		Microcrystalline
-----		-----
Aphanitic	1/256	Cryptocrystalline

Lithology and contacts are adjusted to mechanical logs.

Calstan Mikkwa River 12-23

Location: 12-23-98-21-W4th mer.

Elevation: 2,259 feet K.B.

Total depth: 3,840 feet

Cored intervals: 3,805-3,815; 3,830-3,840.

Depth (feet)	Lithology	Unit thickness (feet)
<u>Keg River Formation</u>		
3,600-3,624	Limestone, light brown, finely crystalline; ostracode fragments.	24
	3,624 <u>Chinchaga Formation</u> 24 feet	
3,624-3,648	Anhydrite, tan, cryptocrystalline; minor dolomite, light brown, very finely crystalline.	24
	3,648 <u>Contact Rapids Formation</u> 110 feet	
3,648-3,725	Shale, green, tan to red in part, dolomitic; minor dolomite and anhydrite, as above.	77
3,725-3,758	Shale, red, dolomitic.	33
	3,758 <u>Cold Lake Formation</u> 38 feet	
3,758-3,776	Samples poor; salt with shale.	18
3,776-3,796	Shale, red, dolomitic.	20
	3,796 <u>Fitzgerald Formation</u> 24 feet	
3,796-3,804	Anhydrite, white to light grey, cryptocrystalline.	8
3,804-3,820	Dolomite, light brown, microcrystalline, bituminous, salt-filled porosity. <u>Planetophyllum</u> <u>planetum</u> at 3,812-3,814 feet.	16
	3,820 <u>La Loche Formation</u> 15 feet	
3,820-3,835	Shale, red, dolomitic, floating quartz grains; becoming sandy in bottom 5 feet.	15
	3,835 <u>Precambrian</u>	
3,835-3,840	Granite.	

Home et al. Fox Lake 4-30

Location: 4-30-108-4-W5th mer.

Elevation: 862 feet K.B.

Total depth: 2985 feet.

Depth (feet)	Lithology	Unit thickness (feet)
<u>Keg River Formation</u>		
2,500-2,530	Limestone, dark gray, finely crystalline, dolomitic.	30
2,530 <u>Chinchaga Formation</u> 179 feet		
2,530-2,590	Anhydrite, tan, cryptocrystalline, minor dolomite, tan, very finely crystalline.	60
2,590-2,671	Anhydrite and dolomite, as above. Anhydrite becoming green in color and argillaceous; interbedded shale, light green, calcareous.	81
2,671-2,709	Shale, light green, becoming red at base, dolomitic.	38
2,709 <u>Cold Lake Formation</u> 175 feet		
2,709-2,861	Samples poor; salt with shale.	152
2,861-2,884	Shale, red, dolomitic.	23
2,884 <u>Fitzgerald Formation</u> 34 feet		
2,884-2,890	Anhydrite, tan, cryptocrystalline,	6
2,890-2,918	Dolomite, tan, microcrystalline, bituminous, salt-filled porosity; minor anhydrite, tan, cryptocrystalline.	28
2,918 <u>La Loche Formation</u> 45 feet		
2,918-2,942	Shale, green, becoming red toward base, dolomitic; minor anhydrite, as above.	24
2,942-2,963	Sandstone, arkosic, medium-grained, red, dolomitic, blebs of anhydrite.	21
2,963 <u>Precambrian</u>		
2,963-2,985	Granite, partially reworked.	

Home et al. Wood Buffalo 14-22

Location: 14-22-110-1-W5 mer.

Elevation: 830 feet K.B.

Total depth: 2425 feet.

Depth (feet)	Lithology	Unit thickness (feet)
<u>Keg River Formation</u>		
1,980-1,992	Limestone, buff to light brown, finely crystalline, dolomitic, bituminous in part; ostracode fragments.	12
1,992 <u>Chinchaga Formation</u> 174 feet		
1,992-2,050	Anhydrite, buff to tan, cryptocrystalline	58
2,050-2,110	Interbedded anhydrite and dolomite. Anhydrite, tan to green, argillaceous in part; dolomite, tan to reddish brown, very finely crystalline.	60
2,110-2,135	Anhydrite, as above; minor dolomite, as above, and shale, light green.	25
2,135-2,166	Shale, green, becoming red at base, dolomitic.	31
2,166 <u>Cold Lake Formation</u> 194 feet		
2,166-2,348	Samples poor; salt with shale.	182
2,348-2,360	Shale, red, dolomitic, silty in part.	12
2,360 <u>Fitzgerald Formation</u> 33 feet		
2,360-2,365	Anhydrite, tan, cryptocrystalline.	5
2,365-2,393	Dolomite, tan, microcrystalline, bituminous partings, salt-filled porosity; minor anhydrite, tan, cryptocrystalline. <u>Welleria meadowlakensis</u> at 2,380-2,385 feet.	28
2,393 <u>La Loche Formation</u> 12 feet		
2,393-2,405	Mudstone, green, dolomitic, floating quartz grains in lower position.	12
2,405 <u>Precambrian</u>		
2,405-2,435	Granite.	

Pan American Pitchimi Lake A-1

Location: 6-11-117-4-W5th mer.

Elevation: 2290 feet K.B.

Total depth: 3952 feet.

Depth (feet)	Lithology	Unit thickness (feet)
<u>Keg River Formation</u>		
3,400-3,418	Dolomite, light brown, finely crystalline	18
	3,418 <u>Chinchaga Formation</u> 206 feet	
3,418-3,490	Anhydrite, white to tan, cryptocrystalline; minor dolomite, tan to light brown, finely crystal- line, and shale, light green, calcareous; trace pyrite.	72
3,490-3,575	Anhydrite, as above, becoming green and argil- laceous; abundant shale, light green, calcareous; minor siltstone, gray.	85
3,575-3,624	Shale, light green to light gray, becoming red toward base, dolomitic in part.	49
	3,624 <u>Cold Lake Formation</u> 260 feet	
3,624-3,876	Samples poor, salt with shale.	252
3,876-3,884	Shale, red, dolomitic.	8
	3,884 <u>Fitzgerald Formation</u> 33 feet	
3,884-3,917	Dolomite, tan, microcrystalline, porous; minor anhydrite, tan, cryptocrystalline.	33
	3,917 <u>La Loche Formation</u> 35 feet	
3,917-3,952	Shale, red, silty, floating quartz grains; basal 10 feet sandy.	35
	3,952 <u>Precambrian</u>	
3,952	Granite.	

Imperial Jack Lakes 8-17

Location: 8-17-120-1-W5th mer.

Elevation: 1442 feet K.B.

Total depth: 2638 feet.

Cored interval: 2566-2638

Depth (feet)	Lithology	Unit thickness (feet)
<u>Keg River Formation</u>		
2,050-2,085	Dolomite, light brown, finely crystalline.	35
	2,085 <u>Chinchaga Formation</u> 209 feet	
2,085-2,152	Anhydrite, tan, cryptocrystalline, dolomite, light brown, microcrystalline, sucrosic.	67
2,152-2,250	Anhydrite, tan to light green, cryptocrystalline, argillaceous in part; minor shale, light green, calcareous, increasing toward base; trace dolomite, as above.	48
2,250-2,294	Shale, red, dolomitic; dolomite, red, microcrystalline, sandy towards base.	44
	2,294 <u>Cold Lake Formation</u> 276 feet	
2,294-2,564	Samples poor; salt with shale.	270
2,564-2,570	Shale, red.	6
	2,570 <u>Fitzgerald Formation</u> 57.4 feet	
2,570-2,606	Anhydrite, dark green, cryptocrystalline; laminations of light gray clay, contorted in places; solution gap filled by secondary halite near upper contact.	36
2,606-2,612.6	Dolomite, dark brown, microcrystalline, very bituminous in part, salt-filled porosity; stylolites at 2,606 feet.	6.6
	2,612.6 <u>La Loche Formation</u> 22.4 feet	
2,612.6-2,619.4	Mudstone, green, floating quartz grains.	6.8

- | | | |
|-----------------|---|------|
| 2,619.4-2,630.3 | Mudstone, tan, reddish in part; blebs of secondary anhydrite, cryptocrystalline, translucent, flowage structure; clasts of mudstone, as above, incorporated in anhydrite; floating quartz grains at 2630-2630.3 feet. | 11.9 |
| 2,630.3-2,633.1 | Anhydrite, alternating bands of light gray and green, slightly argillaceous. Sharp, irregular contacts indicate that anhydrite may be secondary. | 2.8 |
| 2,633.1-2,635 | Sandstone, arkosic, very fine to very coarse-grained, tan; blebs of anhydrite, light gray, cryptocrystalline, vitreous. | 1.9 |

2,635 Precambrian

- | | | |
|-------------|--------------------|--|
| 2,635-2,638 | Granite, reworked. | |
|-------------|--------------------|--|

Pan American Whitesands A-1

Location: 12-20-122-10-W5 mer.

Elevation: 1784 feet K.B.

Total depth: 3871 feet.

Depth (feet)	Lithology	Unit thickness (feet)
<u>Keg River Formation</u>		
3,400-3,413	Dolomite, light brown, finely crystalline.	13
	3,413 <u>Chinchaga Formation</u> 235 feet	
3,413-3,493	Anhydrite, white to tan, cryptocrystalline, dolomite, light brown, microcrystalline, sucrosic.	81
3,493-3,584	Anhydrite, as above, becoming light green in color and argillaceous; minor dolomite, as above; shale, light green, calcareous; trace pyrite and floating quartz grains.	90
3,584-3,648	Shale, green, calcareous, becoming red and dolomitic near base; minor dolomite, red microcrystalline. Tentaculitids at 3,584-3,590 and 3,620-3,630 feet.	64
	3,648 <u>Cold Lake Formation</u> 187 feet	
3,648-3,824	Samples poor; salt with shale.	176
3,824-3,835	Shale, red dolomitic.	11
	3,835 <u>Fitzgerald Formation</u> 33 feet	
3,835-3,868	Dolomite, light brown, microcrystalline, bituminous; minor anhydrite, blue, cryptocrystalline. <u>Welleria meadowlakensis</u> at 3,850-3,860 feet.	33
	3,868 <u>Precambrian</u>	
3,868-3,871	Granite.	

Pyramid 202A

Location: 60°47'42"N, 114°13'49"W
 Elevation: 670.6 feet
 Total depth: 1,138 feet
 Cored interval: all

Depth (feet)	Lithology	Unit thickness (feet)
<u>Pine Point Formation</u>		
570-586	Dolomite, light brown, very finely crystalline	16
586 <u>Chinchaga Formation</u> 337 feet		
586-715	Anhydrite, tan to light brown, cryptocrystalline, dolomitic in part, flowage structures in part; veinlets of clear anhydrite.	129
715-890	Anhydrite, as above; beds of mudstone, green, calcareous.	75
890-923	Anhydrite and mudstone, as above; brecciated in part with fragments of mudstone and anhydrite in green calcareous mudstone; red in part.	33
923 <u>Cold Lake Equivalent</u> 37 feet		
923-960	Breccia, angular fragments of anhydrite, white to green, cryptocrystalline and mudstone, red, dolomitic; red dolomitic mudstone matrix.	37
960 <u>Fitzgerald Formation</u> 41 feet		
960-976	Anhydrite, white to light gray, microcrystalline, disseminated with red mud.	16
976-1,001	Dolomite, tan, micrograined, bituminous, porous. <u>Welleria meadowlakensis</u> at 976-981 feet; undetermined ostracodes from 981-990 feet.	25
1,001 <u>Mirage Point Formation</u> 129 feet		
1,001-1,020	Breccia, angular fragments of mudstone, light gray to green, dolomitic and dolomite, light brown, micrograined, anhydritic; green calcareous mudstone matrix, flowage structures in part; anhydrite at top, white to light brown, microcrystalline.	19

1,020-1,063	Mudstone, red, dolomitic; blebs and veinlets of clear to white anhydrite.	43
1,063-1,067	Anhydrite, light gray to reddish brown, micro-crystalline, disseminated red mud.	4
1,067-1,130	Mudstone, red to green, dolomitic; veinlets and blebs of clear to white anhydrite; disseminated anhydrite in part.	63
1,130 <u>Old Fort Island Formation</u> 108 feet		
1,130-1,155	Sandstone, quartzose, fine- to medium- grained, light gray, blebs of clear anhydrite; mudstone, light gray-green to reddish brown.	25
1,155-1,238	Sandstone, quartzose, fine- to medium- grained, white, red in part, dolomitic cement at top, friable at base; minor siltstone, red; cross-bedding in part with iron staining along bedding planes.	83

Cominco G-1

Location: 60°51'05"N, 114°24'30"W
 Elevation: 724 feet
 Total depth: 1,181 feet
 Cored interval: all
 Summary of log by W. O. Richmond with
 changes by author.

Depth (feet)	Lithology	Unit thickness (feet)
<u>Pine Point Formation</u>		
675-685	Dolomite, light brown, medium crystalline	10
685 <u>Chinchaga Formation</u> 297 feet		
685-750	Interbedded anhydrite and dolomite. Dolomite, light brown, micrograined; anhydrite, light brown, cryptocrystalline, flowage structures, veinlets of clear anhydrite.	65
750-855	Interbedded dolomite and anhydrite, as above; beds of mudstone, green, calcareous.	105
855-963	Anhydrite, tan to light brown, cryptocrystalline, slightly dolomitic in part; veinlets of clear anhydrite; mudstone, green, calcareous.	108
963-982	Anhydrite and mudstone, as above; brecciated in part with fragments of mudstone in anhydrite with flowage structures; red in part.	19
982 <u>Cold Lake Equivalent</u> 51 feet		
982-1,033	Breccia, angular fragments of anhydrite, white to red, cryptocrystalline and mudstone, red, dolomitic; red dolomitic mudstone matrix.	51
1,033 <u>Fitzgerald Formation</u> 39 feet		
1,033-1,049	Anhydrite, white to light brown, mottled, microcrystalline.	16
1,049-1,072	Dolomite, medium brown, micrograined, calcareous, bituminous, porous; trace anhydrite.	23

1,072 Mirage Point Formation 99 feet

1,072-1,089	Anhydrite, light gray, cryptocrystalline; minor mudstone, green, dolomitic.	13
1,085-1,137	Mudstone, red, dolomitic; veinlets of clear to white anhydrite.	52
1,137-1,148	Anhydrite, white to reddish brown, cryptocrystalline, dispersed red mud.	11
1,148-1,171	Dolomite, gray to brown, very fine-grained, argillaceous, abundant quartz grains.	23

1,171 Precambrian

1,171-1,181	Granite.
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Cominco G-4

Location: 60°54'N, 114°46'W.
 Elevation: 539 feet
 Total depth: 1,355 feet
 Cored interval: all
 Summary of log by W. O. Richmond
 with changes by author.

Depth (feet)	Lithology	Unit thickness (feet)
<u>Pine Point Formation</u>		
710-717.5	Dolomite, light brown, very finely crystalline	7.5
	717.5 <u>Chinchaga Formation</u> 315.5 feet	
717.5-720	Dolomite, tan, microcrystalline, sucrosic; veinlets of clear anhydrite.	2.5
720-725	Anhydrite, light brown, cryptocrystalline.	5
725-750	Interbedded dolomite and anhydrite. Dolomite, tan, very fine- to medium-grained, cemented in part by anhydrite; anhydrite, light brown, cryptocrystalline, slightly dolomitic.	25
750-885	Anhydrite, white to light brown, cryptocrystalline; veinlets of clear anhydrite; flowage structures in part; green calcareous mudstone bands from 845-855 feet.	135
889-993	Anhydrite, as above; minor dolomite, tan, micro- crystalline; minor mudstone bands, green, calcareous.	108
993-1,033	Anhydrite and mudstone, as above; brecciated in part with fragments of mudstone in anhydrite with flowage structures; red in part.	40
	1,033 <u>Cold Lake Equivalent</u> 34 feet	
1,033-1,067	Breccia, angular fragments of mudstone, red, dolomitic, matrix of red dolomitic mudstone, blebs of anhydrite.	34

1,067 Fitzgerald Formation 43 feet

1,067-1,086	Anhydrite, white to light brown, mottled, microcrystalline.	19
1,086-1,110	Dolomite, medium brown, micrograined, calcareous, bituminous, porous. Poorly preserved specimens of <u>Welleria meadowlakensis</u> .	24

1,110 Mirage Point Formation 131 feet

1,110-1,126	Anhydrite, white to light brown, cryptocrystalline; dolomite, gray, microcrystalline.	16
1,126-1,196	Mudstone, red, dolomitic; veinlets of clear to white anhydrite.	70
1,196-1,202	Anhydrite, white to light brown, cryptocrystalline; disseminated dolomite grains.	6
1,202-1,241	Mudstone, gray to reddish brown; high content of disseminated anhydrite.	39

1,241 Old Fort Island Formation 101 feet

1,241-1,300	Sandstone, quartzose, fine-grained, maroon, argillaceous matrix, slightly dolomitic; blebs of anhydrite.	59
1,300-1,326	Siltstone, maroon, argillaceous, sandy; minor anhydrite.	26
1,326-1,342	Sandstone, quartzose and feldspathic, light gray to maroon, argillaceous and silty matrix.	16

1,342 Precambrian

1,342-1,355	Granite.	
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Imperial Triad Davidson Creek P-2

Location: 62°11'45"N, 118°15'05"W.

Elevation: 2085 feet K.B.

Total depth: 2737 feet.

Cored intervals: 1,860-1,913; 1,940-1,990; 2,010-2,048;
2,126-2,176; 2,502-2,550.

Core description from 1,860-1,913 feet is summary of log
by H. R. Belyea.

Depth (feet)	Lithology	Unit thickness (feet)
<u>Lonely Bay Formation</u>		
1,860-1,876.5	Limestone and dolomite in rhythmic repetition. Limestone, dark gray to brown, dolomitic; grades down to dolomite, buff, porous.	16.5
1,876-1,876.7	Shale, black, encloses dolomite nodules; abundant pyrite.	0.27
	1,876.7 <u>Chinchaga Formation</u> 279.3 feet	
	1,876.7 <u>Upper Member</u> 150.3 feet	
1,876.7-1,913	Dolomite, tan, very finely crystalline, sucrosic, laminated with black shale; brecciated in part, offsetting of laminae and slump structures; blebs of anhydrite.	36.3
1,913-1,940	Samples poor; probably dolomite and anhydrite, as above and below.	27
1,940-1,969	Interbedded dolomite and anhydrite. Dolomite, tan micrograined, sucrosic, porous; anhydrite, light gray, cryptocrystalline; clear anhydrite in part replacing dolomite.	29
1,969-1,970	Shale, light green, waxy; minor pyrite.	1
1,970-1,990	Banded dolomite and anhydrite. Dolomite, tan, aphanitic to micrograined, argillaceous in part; anhydrite, brown, cryptocrystalline.	20
1,990-2,010	Samples poor; anhydrite and dolomite, as above.	20
2,010-2,012	Anhydrite, brown, cryptocrystalline.	2
2,012-2,025	Mudstone, green to brown, dolomitic; blebs of clear anhydrite.	13

2,025-2,027	Interlayered anhydrite and mudstone, as above.	2
	2,027 <u>Lower Member</u> 129 feet	
2,027-2,048	Anhydrite, dark gray cryptocrystalline, argillaceous in part.	21
2,048-2,126	Samples poor; dolomite, light brown, microcrystalline; anhydrite, light gray, cryptocrystalline; minor shale, green.	78
2,126-2,129	Dolomite, brown, micrograined, argillaceous, anhydritic.	3
2,129-2,138	Dolomite, as above, red in color; blebs of clear anhydrite; contorted in bottom 2 feet.	9
2,138-2,151	Mudstone, red, dolomitic; blebs and veinlets of anhydrite; considerable brecciation.	13
2,151-2,156	Breccia, angular fragments of red dolomitic mudstone, red dolomitic mudstone matrix.	5
	2,156 <u>Lower Elk Point Evaporites</u> 414 feet	
2,156-2,173	Halite, clear, recrystallized, dispersed red mud.	17
2,173-2,174	Anhydrite, brown, cryptocrystalline.	1
2,174-2,175	Mudstone, red.	1
2,175-2,176	Anhydrite, as above.	1
2,176-2,372	Samples poor; salt and minor anhydrite.	216
2,372-2,386	Mudstone, red, dolomitic.	14
2,386-2,450	Samples poor; probably dolomite.	64
2,450-2,502	Samples poor; probably dolomite, light brown, finely crystalline; minor anhydrite and red shale.	52
2,502-2,540	Anhydrite, dark gray, microcrystalline; dolomite, light brown, microcrystalline, salty. Interbedded salt and anhydrite from 2,525-2,529 feet.	38
2,540-2,570	Samples poor; dolomite, light brown, microcrystalline.	30

2,570 Mirage Point Formation 120 feet

2,570-2,580	Samples poor; anhydrite.	10
2,580-2,590	Shale, red, dolomitic, coarse quartz grains.	10
2,590-2,610	Shale, as above; dolomite, maroon, microcrystalline.	20
2,610-2,660	Shale, green, waxy.	50
2,660-2,690	Shale, as above; dolomite, tan, microcrystalline.	30

2,690 Old Fort Island Formation 15 feet

2,690-2,705	Sandstone, quartzose, fine- to coarse-grained, white.	15
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2,705 Precambrian

2,705-2,737	Granite.	
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Imperial Triad Willow Lake B-20

Location: 62°17'13"N, 119°04'20"W.

Elevation: 2,438 feet K.B.

Total depth: 3,229 feet.

Cored intervals: 2,220-2,239; 3,000-3,019.

Depth (feet)	Lithology	Unit thickness (feet)
<u>Lonely Bay Formation</u>		
2,220-2,235	Limestone, brown, very fine-grained, dolomitic.	15
	2,235 <u>Chinchaga Formation</u> 331 feet	
	2,235 <u>Upper Member</u> 174 feet	
2,235-2,340	Dolomite, light brown, micrograined, styalitic in part, porous.	105
2,340-2,383	Dolomite, gray to light brown, cryptocrystalline; blebs of clear anhydrite.	43
2,383-2,409	Mudstone, gray to green, dolomitic.	23
	2,409 <u>Lower Member</u> 157 feet	
2,409-2,558	Anhydrite, gray to brown, cryptocrystalline.	149
2,558-2,566	Mudstone, red, dolomitic.	8
	2,566 <u>Lower Elk Point Evaporites</u> 474 feet	
2,566-2,861	Samples poor; salt and minor anhydrite.	295
2,861-2,867	Mudstone, red, dolomitic.	6
2,867-2,942	Samples poor; probably dolomite with minor anhydrite.	75
2,942-2,991	Samples poor; salt with minor anhydrite.	49
2,991-3,040	Limestone, light to dark brown, mottled, microcrystalline, sucrosic, salty; becoming green and shaly near base.	49

3,040 Mirage Point Formation 80 feet

3,040-3,050	Anhydrite, white, cryptocrystalline.	10
3,050-3,120	Dolomite, maroon, micrograined, argillaceous, sandy toward base.	70

3,120 Old Fort Island Formation 28 feet

3,120-3,148	Sandstone, quartzose, very fine-grained, red, dolomitic, argillaceous.	24
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3,148 Precambrian

3,148-3,229	Granite.	
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Imperial Triad Harris River F-71

Location: 62°20'21"N. 120°14'30"W.

Elevation: 2,343 feet K.B.

Total depth: 3,314 feet.

Cored interval: 2,279-2,297.

Depth (feet)	Lithology	Unit thickness (feet)
<u>Lonely Bay Formation</u>		
2,200-2,235	Limestone, tan, cryptocrystalline.	35
	2,235 <u>Chinchaga Formation</u> 523 feet	
	2,235 <u>Upper Member</u> 195 feet	
2,235-2,279	Interbedded limestone and dolomite, limestone, medium brown, aphanitic; dolomite tan, microcrystalline; minor green shale; trace pyrite.	44
2,279-2,296	Limestone, light to dark gray, mottled, micrograined, stylolitic.	17
2,296-2,340	Dolomite, light brown, micrograined; trace pyrite.	44
2,340-2,305	Dolomite, tan, micrograined; blebs of clear anhydrite; cryptocrystalline at bottom.	65
2,405-2,430	Mudstone, gray to green, dolomitic.	25
	2,430 <u>Lower Member</u> 328 feet	
2,430-2,746	Samples poor; anhydrite, white to light gray, cryptocrystalline; minor dolomite.	316
2,746-2,758	Shale, green.	12
	2,758 <u>Lower Elk Point Evaporites</u> 494 feet	
2,758-3,030	Samples poor; salt with minor anhydrite.	272
3,030-3,040	Samples poor; probably dolomite and shale.	10
3,040-3,124	Samples poor; dolomite with minor anhydrite.	84
3,124-3,192	Samples poor; salt with minor anhydrite.	68

3,192-3,252	Dolomite, tan to light brown, micrograined; minor anhydrite, gray, cryptocrystalline.	60
	3,252 <u>Mirage Point Formation</u> 33 feet	
3,292-3,260	Anhydrite, gray, cryptocrystalline.	8
3,260-3,285	Samples poor; probably dolomite and shales.	25
	3,285 <u>Old Fort Island Formation</u> 22 feet	
3,285-3,307	Interbedded sandstones and shales: Sandstone, quartzose, red, fine-grained, argillaceous; shale, red, dolomitic.	22
	3,307 <u>Precambrian</u>	
3,307-3,314	Granite.	

Imperial Windflower G-77

Location: 62°56'23"N. 118°59'00"W.

Elevation: 903 feet K.B.

Total depth: 1,644 feet.

Cored interval: 1,350-1,370.

Depth (feet)	Lithology	Unit thickness (feet)
<u>Lonely Bay Formation</u>		
310-320	Limestone, tan to light brown, micrograined.	10
320-330	No sample.	10
330 <u>Chinchaga Formation</u> 550 feet		
330 <u>Upper Member</u> 213 feet		
330-385	Interbedded limestone and dolomite. Limestone, tan, aphanitic, dolomitic; dolomite, medium brown micrograined.	55
385-424	Limestone, tan to light brown, micrograined, dolomitic; calcite crystals.	39
424-450	Dolomite, tan to light brown, very fine- to fine-grained, calcareous, porous; calcite crystals.	26
450-463	Dolomite, light brown, aphanitic; blebs of light brown anhydrite.	13
463-503	Anhydrite, white to light brown, cryptocrystalline, dolomitic in part.	40
503-526	Mudstone, gray to green, dolomitic.	23
526-534	Anhydrite, brown, cryptocrystalline.	8
534-543	Mudstone, as above.	9
543 <u>Lower Member</u> 337 feet		
543-650	Anhydrite, tan to light brown, cryptocrystalline; minor dolomite, tan, microcrystalline.	107
650-690	Anhydrite, light gray to brown, microcrystalline.	40
690-700	No sample.	10
700-765	Anhydrite, white to light gray, argillaceous in part, dolomitic in part.	65

765-780	Dolomite, medium brown, very fine-grained, sucrosic; blebs of anhydrite.	15
780-790	No sample.	10
790-865	Dolomite, light brown, micrograined to very fine-grained, sucrosic, porous; blebs of anhydrite.	95
865-880	Mudstone, gray to green, calcareous; blebs of anhydrite.	15
880 <u>Chedabucto Lake Formation</u> 275 feet		
880-890	Dolomite, light brown, fine-grained, vuggy porosity.	10
890-930	Dolomite, tan, micrograined, vuggy.	40
930-940	No sample.	10
940-968	Dolomite, as above.	28
968-980	Mudstone, gray to green, dolomitic.	12
980-1,100	Dolomite, tan to light brown, weathers orange in part, micrograined; blebs of anhydrite; becomes shaly in bottom 10 feet; minor pyrite.	120
1,100-1,120	Shale, gray to green, dolomitic; dolomite, light brown, micrograined, argillaceous.	20
1,120-1,155	Dolomite, gray to brown, micrograined; interbeds of gray siltstone; floating quartz grains.	35
1,155 <u>La Martre Falls Formation</u> 465 feet		
1,155 <u>Upper La Martre Falls Formation</u> 270 feet		
1,155-1,185	Interbedded siltstone and shale. Siltstone, gray, glauconitic, micaceous, dolomitic, quartz grains, shale, green, micaceous.	30
1,185-1,260	Shale, gray to green, red in part, silty in part, dolomitic.	75
1,260-1,270	No sample.	10
1,270-1,425	Interbedded siltstone and shale. Siltstone, quartzose, light gray, micaceous, glauconitic dolomitic; shale, green, dolomitic; red in part; laminae of anhydrite in places.	155
1,425 <u>Mazenod Member</u> 65 feet		
1,425-1,460	Interbedded shale and dolomite. Dolomite, gray to brown, finely crystalline rhombs; shale, dark gray to green.	35

1,460-1,490	Dolomite, as above.	30
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1,490 Lower La Martre Falls Formation 130 feet

1,490-1,500	No sample.	10
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1,500-1,510	Shale, gray, waxy.	10
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1,510-1,520	No sample.	10
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1,520-1,550	Shale, gray to green, waxy.	30
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1,550-1,620	No samples.	70
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1,620 Precambrian

1,620-1,644	Granite.	
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Imperial Cartridge B-72

Location: 63°11'19"N. 120°29'04"W.

Elevation: 1,429 feet K.B.

Total depth: 2,258 feet.

Cored intervals: 900-943; 1,021-1,062; 1,070-1,093;
1,094-1,108; 1,112-1,137; 1,286-1,301; 1,410-1,415;
1,440-1,448; 1,620-1,623; 2,041-2,045; 2,081-2,098.

Depth (feet)	Lithology	Unit thickness (feet)
<u>Lonely Bay Formation</u>		
900-912	Limestone, medium-brown, micrograined; fossil debris.	12
912 <u>Chinchaga Formation</u> 728 feet		
912 <u>Upper Member</u> 190 feet		
912-924	Mudstone, gray to green, calcareous, shaly in part.	12
924-963	Limestone, medium to dark brown, micrograined; calcite crystals; fossil debris; trace pyrite.	39
963-985	Interbedded limestone and mudstone, limestone, as above; mudstone, gray to green, calcareous.	22
985-1,058	Dolomite, light brown, micrograined, bituminous, calcite crystals, strolitic.	73
1,058-1,073	Dolomite, light gray to green, argillaceous.	15
1,073-1,098	Breccia, angular fragments of light gray to light green dolomitic mudstone, dark green dolomitic mudstone matrix.	25
1,098-1,102	Dolomite, light brown, microcrystalline, sucrosic, bituminous.	4
1,102 <u>Lower Member</u> 538 feet		
1,102-1,170	Anhydrite, white to light gray, microcrystalline.	68
1,170-1,195	Dolomite, tan, micrograined; blebs of clear anhydrite.	25
1,195-1,220	Anhydrite, white to light gray, cryptocrystalline.	25

1,220-1,240	No samples.	20
1,240-1,291	Anhydrite, dark gray, microcrystalline, disseminated red mud.	51
1,291-1,304	Mudstone, red, dolomitic; blebs and veinlets of anhydrite, white to gray, cryptocrystalline.	13
1,304-1,392	Anhydrite, white to gray, microcrystalline.	88
1,392-1,420	Limestone, medium brown, micrograined, dolomitic, bituminous, styolitic.	28
1,420-1,490	Dolomite, medium brown, micrograined, styolitic; minor mudstone, green. Devonian ostracodes from 1,440-1,450 feet.	22
1,490-1,902	Anhydrite, white to gray, cryptocrystalline.	12
1,502-1,920	Dolomite, dark brown, microcrystalline, sucrosic.	18
1,520-1,610	Anhydrite, white to gray, cryptocrystalline.	90
1,610-1,620	Dolomite, gray to brown, microcrystalline, argillaceous; blebs of clear anhydrite.	10
1,620-1,630	Dolomite, as above, very argillaceous, floating quartz grains; sandstone, quartzose, very fine- to fine-grained, argillaceous and dolomitic matrix.	10
1,630-1,640	Sandstone, as above.	10
	1,640 <u>Chedabucto Lake Formation</u> 383 feet	
1,640-1,800	Dolomite, light gray to brown, cryptocrystalline for most part; trace pyrite.	160
1,800-2,020	Dolomite, dark gray to brown, mottled in part, micrograined, becoming cryptocrystalline at bottom, styolitic in part.	220
2,020-2,040	No samples.	20
	2,023 <u>La Martre Falls Formation</u> 214 feet	
2,040-2,080	Sandstone, quartzose, medium- to coarse-grained, light gray, dolomitic cement; shale, light gray to green, dolomitic.	40
2,080-2,098	Interbedded siltstone and shale. Siltstone, gray to green; shale, green.	18
2,098-2,140	Interbedded siltstone and shale. Siltstone, gray to green, sandy; shale, green, waxy.	42

2,140-2,150 No sample. 10

2,150-2,237 Interbedded siltstone and shale, as above.

2,237 Precambrian

2,237-2,258 Granite.

Imperial Lac Tache C-35

Location: 63°44'15"N. 120°36'45"W.

Elevation: 1,014 feet K.B.

Total depth: 1,719 feet.

Cored intervals: 350-365; 853-872; 873-881.

Depth (feet)	Lithology	Unit thickness (feet)
<u>Cretaceous Shales</u>		
300-330	Shale, dark gray to black, floating quartz grains; trace coal.	30
330-335	Sandstone, quartzose, fine-grained, white calcareous cement.	5
335 <u>Chinchaga Formation</u> 472 feet		
335 <u>Upper Member</u> 173 feet		
335-347	Shale, green, calcareous.	12
347-360	Dolomite, gray to green, very fine-grained, argillaceous; veinlets of clear anhydrite.	13
360-370	Shale, gray to brown, dolomitic.	10
370-385	Dolomite, light brown, very fine grained, sucrosic, porous.	15
385-402	Dolomite, gray to green, aphanitic, argillaceous.	17
402-508	Dolomite, gray to brown, very fine-grained, porous.	106
508 <u>Lower Member</u> 299 feet		
508-566	Anhydrite, white to light gray, cryptocrystalline.	58
566-594	Dolomite, gray to green, aphanitic, argillaceous, blebs of clear anhydrite.	28
594-676	Anhydrite, white to gray, cryptocrystalline.	82
676-685	Dolomite, gray to green, aphanitic, argillaceous.	9
685-744	Anhydrite, white to light brown, cryptocrystalline.	59
744-807	Dolomite, gray to green, aphanitic, argillaceous, floating quartz grains; interbeds of shale, green, dolomitic.	61

807 Chedabucto Lake Formation 483 feet

807-830	Anhydrite, gray to brown, mottled, cryptocrystalline, dolomitic.	23
830-1,068	Rhythmic dolomite, gray to brown, cryptocrystalline, sucrosic blebs of anhydrite; gray to brown, micrograined, porous.	238
1,068-1,200	Dolomite, dark gray to brown, micrograined; trace pyrite.	122
1,200-1,290	Dolomite, as above, floating quartz grains, calcite crystals.	90

1,290 La Martre Falls Formation 429 feet

1,290-1,316	Sandstone, quartzose, gray, fine-grained, argillaceous and dolomitic matrix; minor dolomite, as above.	26
1,316-1,384	Dolomite, gray to brown, cryptocrystalline, abundant quartz grains; minor shale, green, dolomitic; trace pyrite.	68
1,384-1,396	Sandstone, quartzose, fine-grained, dolomitic cement.	12
1,396-1,404	Dolomite, gray to green, cryptocrystalline, argillaceous, abundant quartz grains.	8
1,404-1,719	Sandstone, arkosic, medium- to coarse-grained, white to red, dolomitic and argillaceous matrix; conglomeratic toward base; trace pyrite.	315

A'

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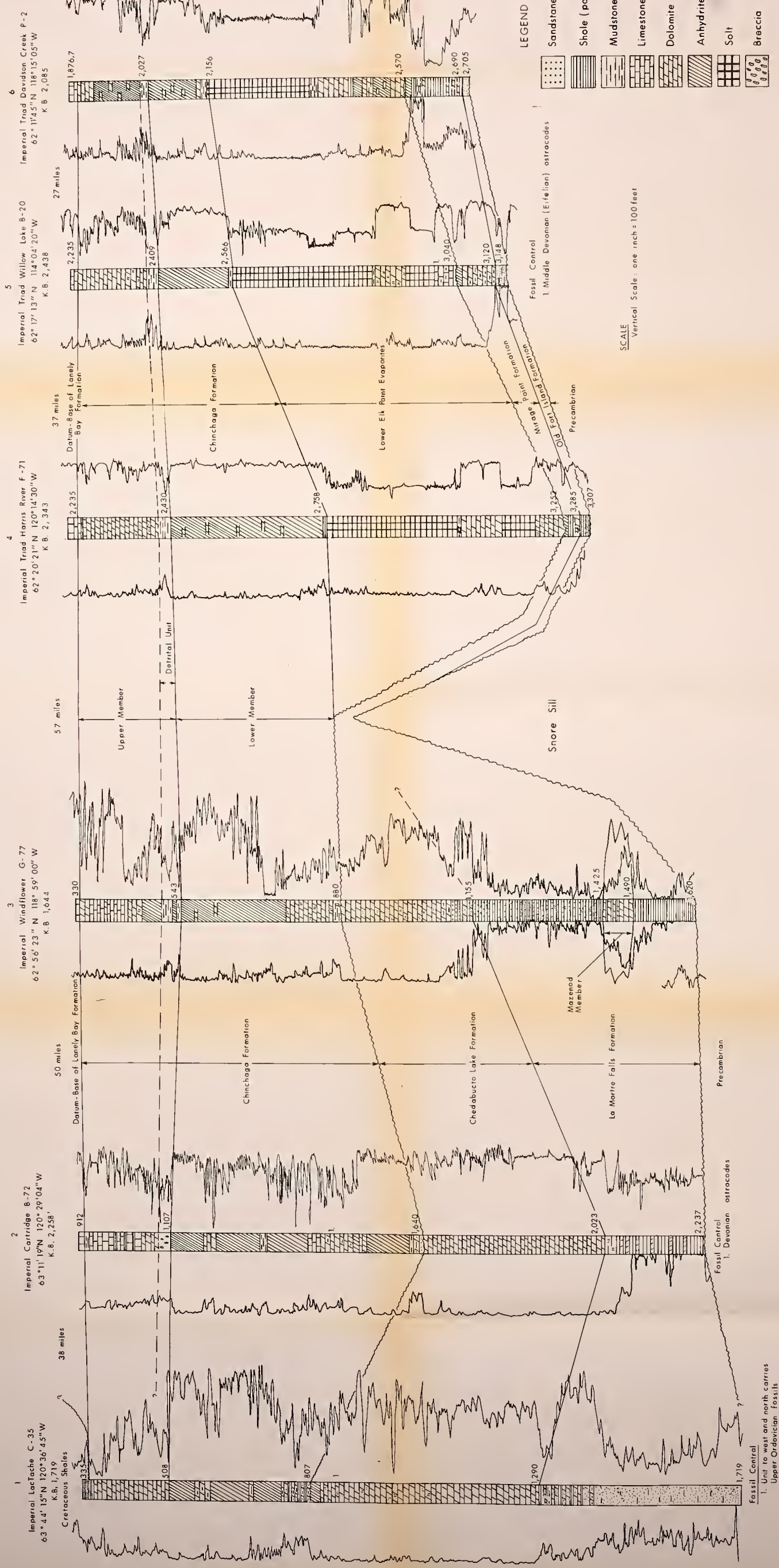


FIGURE 3 STRATIGRAPHIC CROSS-SECTION A-A'
 Imperial Lac Tache C-35 to Imperial Triad Davidson Creek P-2

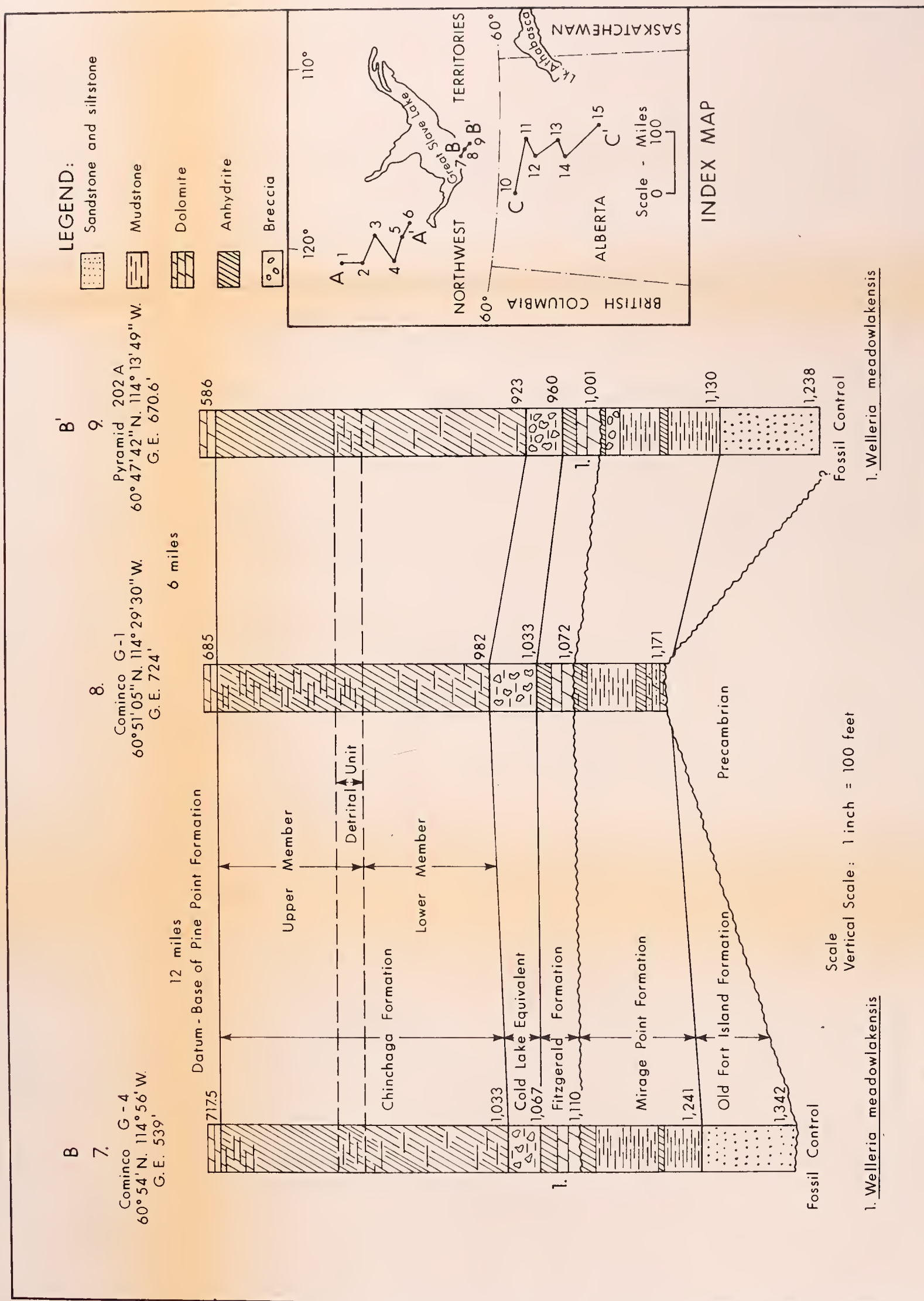


FIGURE 4 STRATIGRAPHIC CROSS-SECTION B-B' . COMINCO G-4 to PYRAMID 202 A

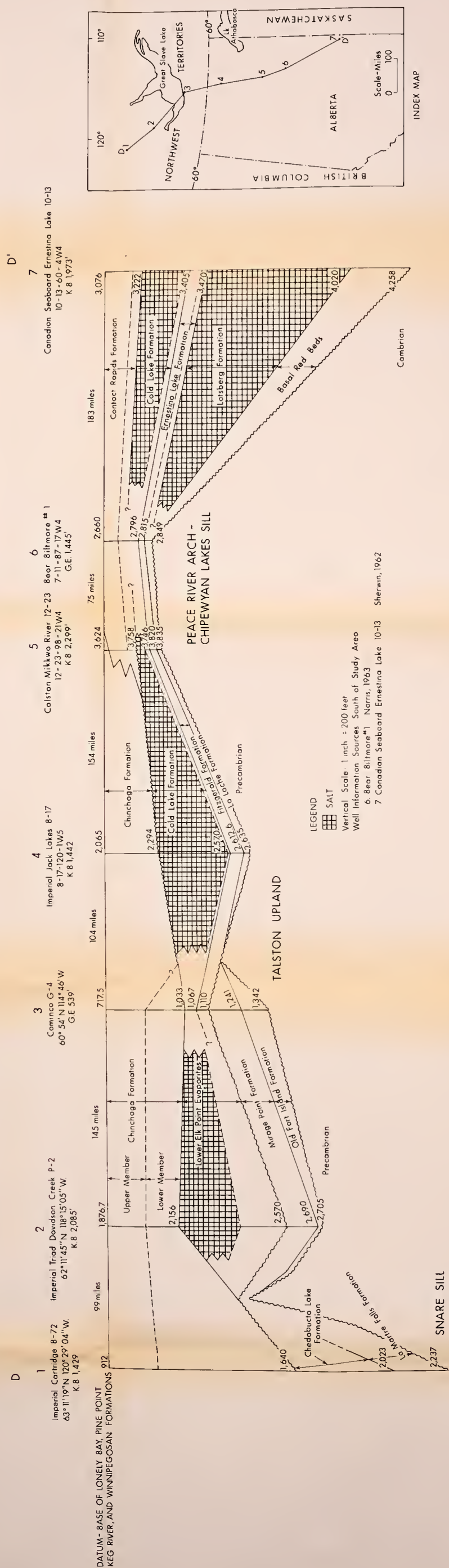


FIGURE 6 SCHEMATIC CROSS-SECTION D-D' IMPERIAL CARTRIDGE 8-72 TO CANADIAN SEABOARD ERNESTINA LAKE 10-13

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